# Compressed Air Magazine

MAY 1943


NAVY AVENGERS

VOLUME 48 · NUMBER 5

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## ON THE COVER

THE highs and lows of aerial fighting are encountered by the Grumman Avengers shown on our front cover. They are the Navy's new torpedo bombers, capable both of hedge-hopping the waves to press home a torpedo attack and of soaring high over enemy targets. They operate from carriers and are usually accompanied by fighter planes, a combination capable of brilliant teamwork, particularly in low-level attacks.

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## IN THIS ISSUE

EVER stop to wonder why modern planes can soar to incredible altitudes —heights that enable them to escape anti-aircraft fire? The answer is supercharging, and Paul Hoffman, an eminent engineer, tells you about it in our feature article.

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LITTLE more than an interesting relic a few years ago, the old Oxford Furnace at Oxford, N. J., again comes into the limelight as a war industry springs up near by. The life story of the furnace and the vital future of the area surrounding it are ably discussed by Rev. A. G. Yount.

•

YOU probably don't like dark, soggy potatoes and skinny, undernourished fruit. But these unpalatable qualities would be present in many of our foodstuffs were it not for the element known as potash. Fremont Kutnewsky relates how America, in the past quarter-century, has built up an adequate supply of this priceless ingredient.

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THE manufacture of plywood has been deemed essential to our war effort, and Henry W. Young tells of a development that speeds production considerably.

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CONSERVATION of steel has been aided by a new type of construction employing wood. A brief item describes the metal timber connectors that provide the margin of safety.

# Compressed Air Magazine



VOLUME 48 **May, 1943** NUMBER 5

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## EDITORIAL CONTENTS



## ADVERTISING INDEX



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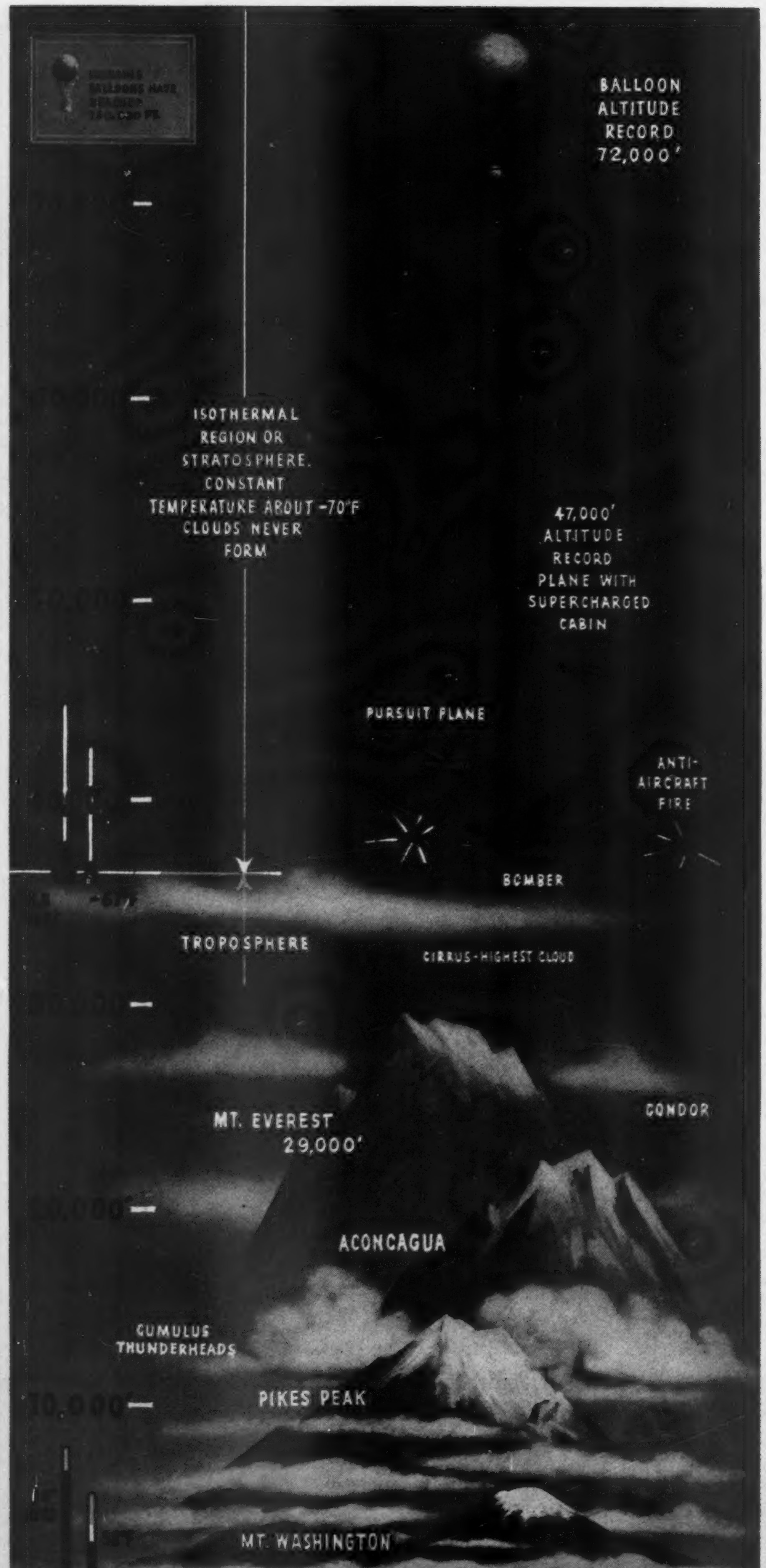
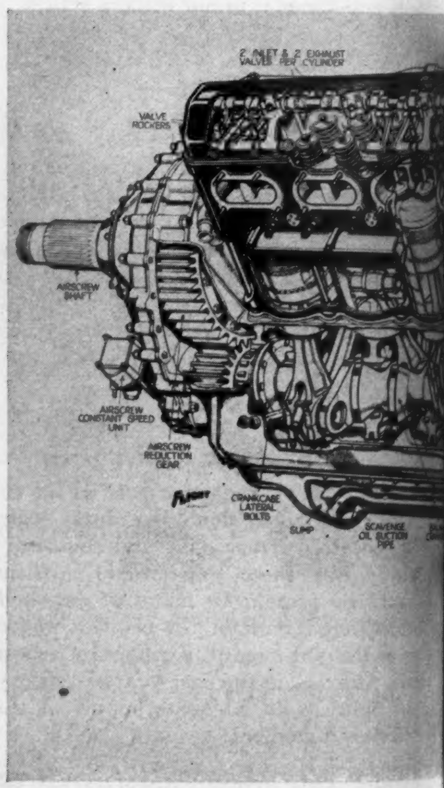


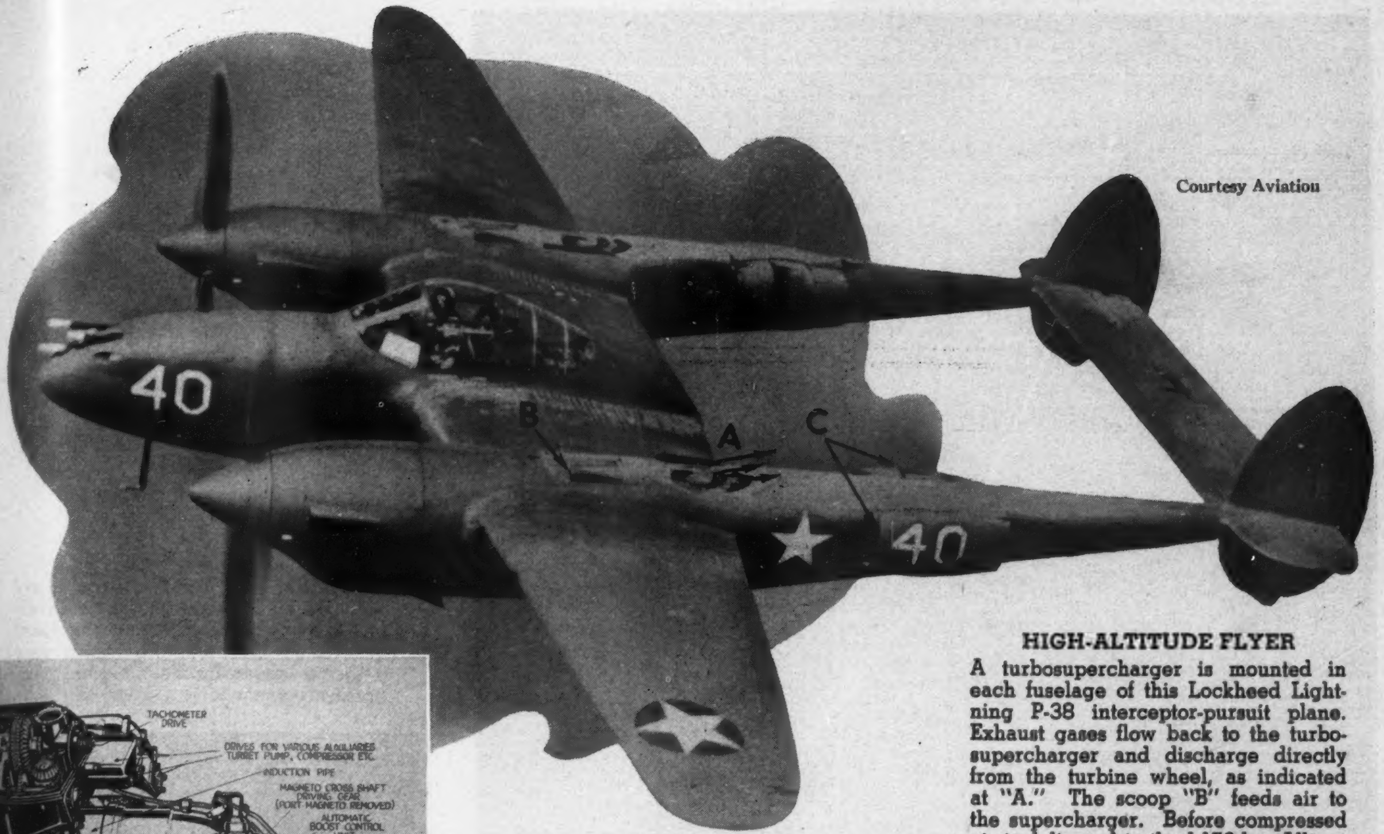

# Supercharging Aircraft Engines

## Part I

*Paul Hoffman*



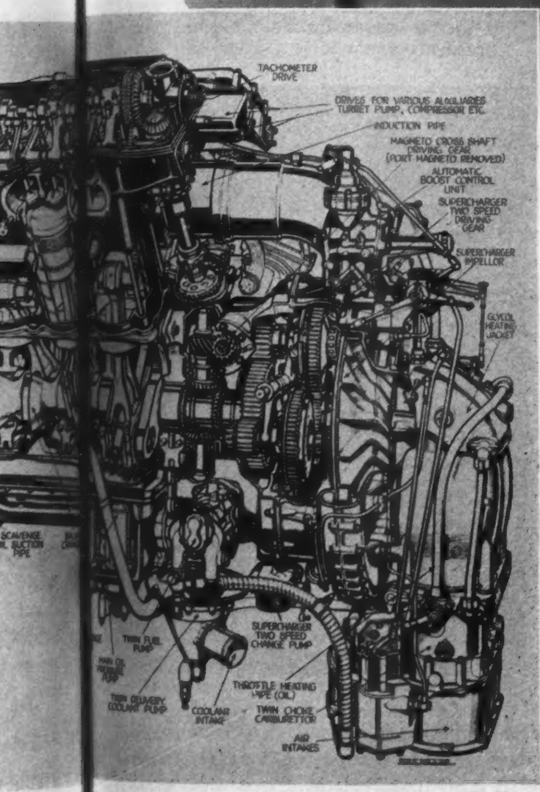

**T**HE ability to fly higher than the enemy is an all-important advantage in aerial warfare. To the fighter, it means power to strike at his quarry from above; to the bomber, high altitude means escape from antiaircraft fire. No wonder, then, that the keen competition for altitude supremacy has pushed the flying and fighting ceiling of military aircraft ever higher, until today it has reached the stratosphere. While it is common knowledge that high-altitude flying requires supercharging of the engine, the why and how of supercharging are not so generally understood. These questions involve certain basic principles in compressing air, which we propose to discuss




Courtesy Aviation

**HIGH-ALTITUDE FLYER**

A turbosupercharger is mounted in each fuselage of this Lockheed Lightning P-38 interceptor-pursuit plane. Exhaust gases flow back to the turbosupercharger and discharge directly from the turbine wheel, as indicated at "A." The scoop "B" feeds air to the supercharger. Before compressed air is delivered to the 1,150-hp. Allison engine, it is passed through a liquid-cooled heat exchanger—aftercooler. The cooling liquid used for both the aftercooler and the engine is ethylene glycol, heat from which is dissipated through radiators in the air tunnels at "C."




(C) Flight

**MAZE OF PARTS**

Typical of the superchargers gear-driven from the engine shaft is the one at the right-hand end of the Merlin XX Rolls-Royce shown at the left. The 2-speed transmission gives some degree of flexibility, but is not capable of adapting itself exactly to the varying demands imposed upon the supercharger at different altitudes.

without elaborating on the technical details.

At the outset it will be useful to consider briefly the working principles of the internal-combustion engine. This follows the pattern of all so-called heat engines. A working medium (air, gas, vapor) is compressed, then caused to assume a higher pressure and volume by the introduction of heat so that, in the expansion which follows, it will yield more work than was required in its compression. In the internal-combustion engine this cycle of operations ordinarily takes place in each cylinder. At the beginning of the cycle the working medium is air; that is, a mixture of oxygen and nitrogen. Heat is introduced by the combustion of a petroleum fuel within the cylinder. This may either be injected in liquid form at the end of the compression stroke of the piston or drawn into the cylinder as a vapor, together with the air, during the suction stroke. In the first case—that of the solid-injection engine—combustion is spontaneous because the temperature of the highly compressed air exceeds the fire point of the fuel; in the second case—that of the carburetor-type engine—combustion is induced by a spark. Either way, the rate of combustion is extremely fast because of the concentration of oxygen through compression, and the combustion has the character of an explosion with rapid pressure rise. The oxygen in the air combines with the chemical constituents of the fuel, chiefly hydrocarbons, to form the combustion gases: carbon monoxide, carbon dioxide, water vapor, etc. These participate with the heated nitrogen—the inert component of the air—in driving the piston through the expansion stroke, after which they are exhausted to the atmosphere.

It is evident that the power produced by an engine depends primarily upon how much fuel can be burned, or heat generated, in each cylinder. (Naturally, it also depends upon how well this heat is utilized; that is, upon the thermal and mechanical efficiency of the engine. But these factors do not interest us here.) However, the maximum amount of fuel that can be burned is fixed by the amount of available oxygen. Each cylinderful of air drawn from the atmosphere contains a certain weight of oxygen (23 per cent of that of the air), and this can combine, chemically, with just so much fuel and with no more. When this precise air-to-fuel ratio prevails, we have perfect and complete combustion. If too little or too much fuel is fed into the air, the mixture is said to be either too lean or too rich. When it is too lean, the engine does not develop its full power; when it is too rich, the engine smokes (that is, unburned carbon particles are expelled with the exhaust gases) and various mechanical troubles soon develop.

From the foregoing it is clear that if the density of the atmospheric air decreases—and this is what happens as the altitude increases—then less fuel can be completely burned in each cylinder; and, consequently, the engine horsepower falls off. Now as a matter of fact, the factors controlling the density of air, or of any other gas, are two: the pressure exerted upon it, and its temperature. Mathemat-

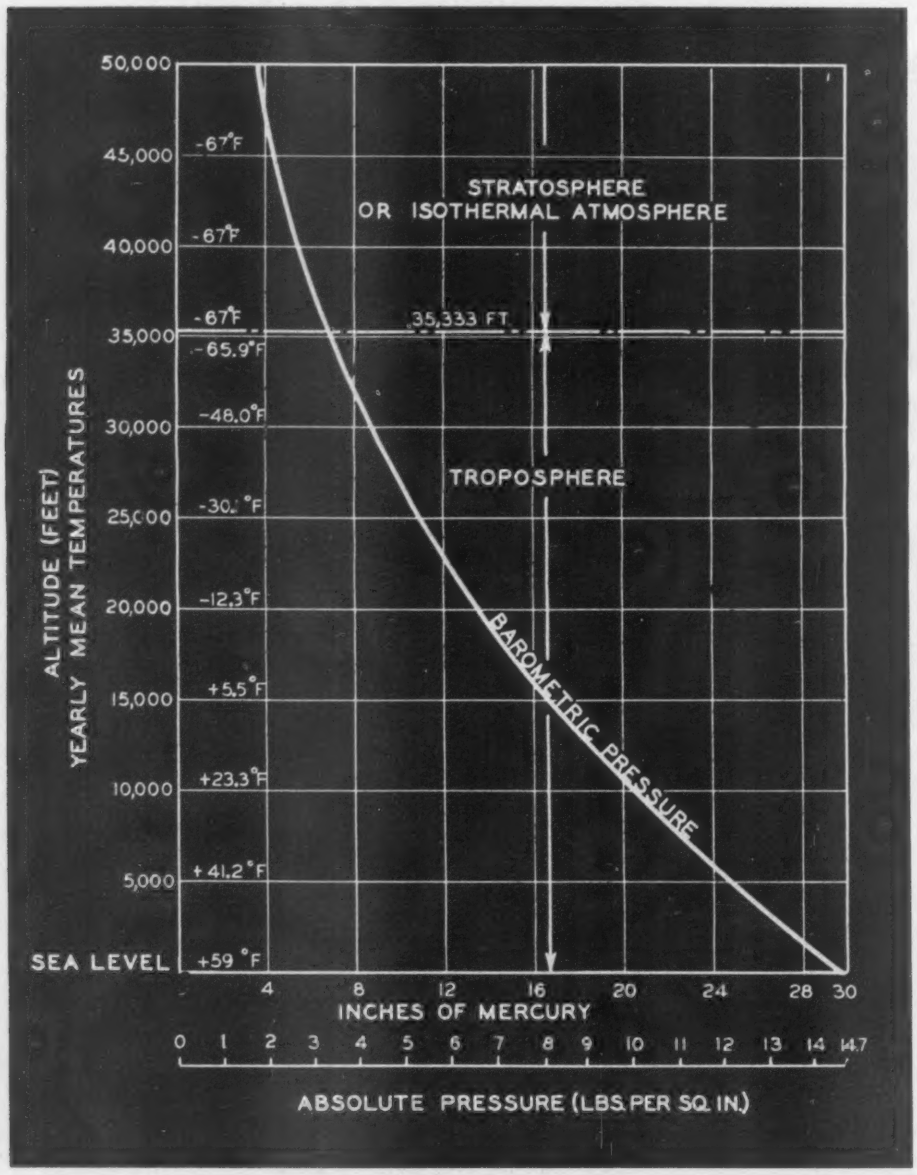
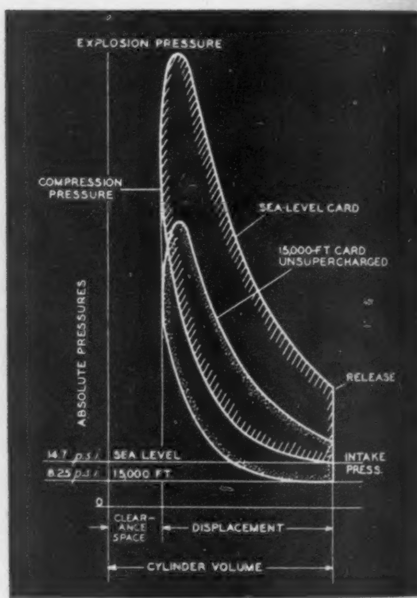



**FIGURE 1**

**Standard atmosphere. This is agreed upon by physicists and aeronautical engineers as a working basis in figuring pressures and temperatures at different altitudes. It represents yearly mean conditions at 42° latitude. Actual conditions may vary considerably from standard.**

**FIGURE 2**

**Comparison of indicator cards at sea level and at 15,000 feet altitude for an unsupercharged engine. Card areas and indicated horsepower vary with the pressures reached in compression.**




ically expressed, the density varies directly with the absolute pressure (the barometric pressure in the case of atmospheric air) and inversely with the absolute temperature—460°, plus the Fahrenheit thermometer reading. It remains to be seen, therefore, how the absolute pressure and temperature of the atmosphere change with altitude.

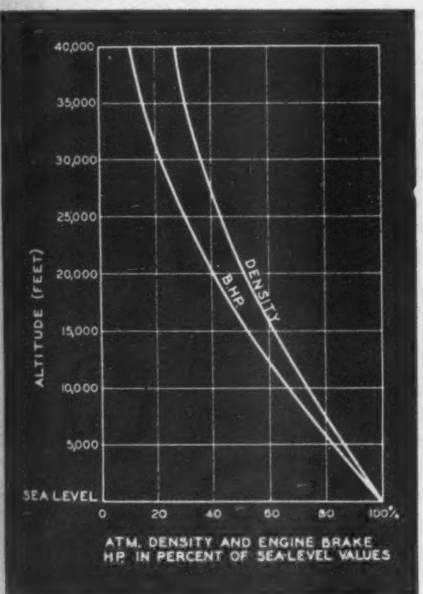
Everyone is more or less familiar with the general effect of altitude upon atmospheric pressure. We all know that the layer of some 500 miles of atmospheric air which surrounds the earth is heaviest at the bottom and thins out gradually to what is assumed to be the absolute vacuum of outer space. We also appreciate that the atmospheric pressure at any one point is due to the weight of the air above it. Now, a column of air 1 square inch in cross section and reaching from sea level to the outermost limit of the atmosphere weighs 14.72 pounds, since it can be held in equilibrium by a column of mercury 29.92 inches high. Hence, we say that the atmospheric pressure at sea level is 14.7 pounds per square inch, or that the barometer reads 30 inches. (These are, of course, mean values.) As we rise to higher levels, the superimposed weight of the air and, with it, the atmospheric pressure decrease and the barometer falls. This takes place at a gradually diminishing rate. For example, at an altitude of 1 mile the pressure is 12.1 pounds per square inch, having dropped 2.6 pounds per square inch. At 2 miles above sea level the pressure has dropped an additional 2.2 pounds to 9.9 pounds per square inch; at 3 miles it has fallen 1.9 pounds further to 8 pounds per square inch, etc.

Regarding the temperature of the atmosphere, the prevailing notions are apt to be more vague. Contrary to popular belief, the air is heated very little by the sun's radiation but rather by contact with and convection from the earth's surface, as well as through the effect of rising warm air currents containing water vapor. As the distance from its source of heat increases, the air becomes cooler. On an average, the drop in temperature approximates 1°F. for every 280 feet of elevation above sea level, and it continues at this rate until about -67°F. is reached. So far as is known, the temperature remains constant from there on, and that is why this upper region is designated as the isothermal atmosphere. It also goes by the name of stratosphere, while the lower region is known as the troposphere. The dividing line is, roughly, at an altitude of 35,000 feet; and, incidentally, this marks also the upper limit of cloud formation.

For the convenience of physicists and

**FIGURE 3**

So-called derating curve for unsupercharged internal-combustion engines, showing loss of brake horsepower with increasing altitude. Power drops faster than the density of atmospheric air.



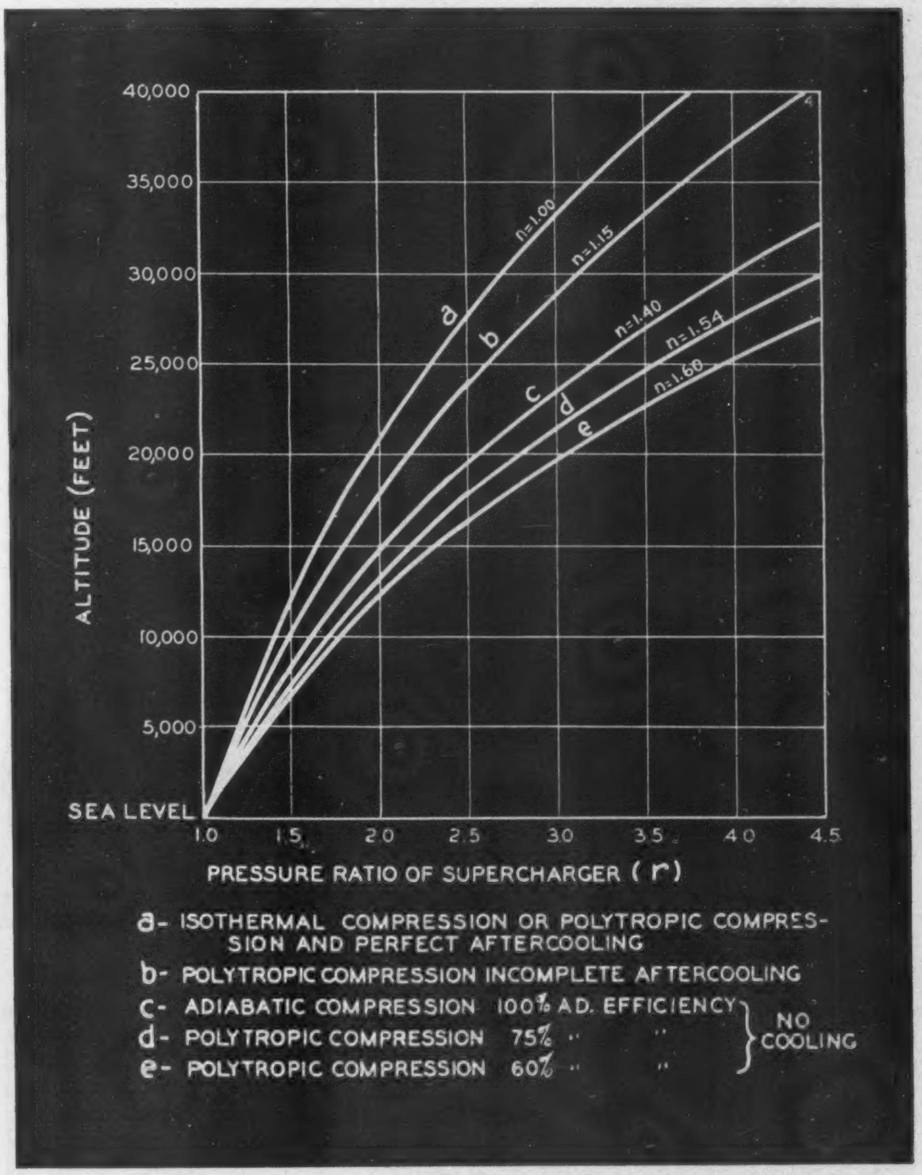




**FIGURE 4**

Required rate of supercharging to maintain constant air density in the engine intake manifold and constant brake horsepower of the engine. Different modes of compression are shown, and the altitude on the chart is limited to 40,000 feet. Beneficial effect of cooling and of high compression efficiency is clearly illustrated.

aeronautical engineers, the so-called standard atmosphere has been agreed upon. This assumes, more or less arbitrarily, fixed values of pressure and temperature for given altitudes, corresponding to the observed yearly means at about 40° latitude. Figure 1 shows the pressure and temperature of the standard atmosphere up to an altitude of 50,000 feet. From these data the relative density of the air at different altitudes can be easily computed. If $d$ denotes density, $P$ absolute pressure, $T$ absolute temperature, and if the subscripts $a$ are used for altitude and $o$ for sea level, then

$$d_a = d_o \frac{P_a}{P_o} \frac{T_o}{T_a}$$

We must now look more closely at the statement made while discussing engines, namely, that it is the density of the air which determines the amount of fuel that can be burned in a given cylinder. Strictly speaking, it is not the density of the atmosphere that counts, but the density of the air in the cylinder after the suction stroke has been completed. And this is affected to some degree by the absorption of heat as the fresh air fills the cylinder, contacts the hot cylinder walls, and mixes with the residual spent gases. Therefore, the power developed in the cylinder does not vary directly with the density of the atmosphere, but at a somewhat different rate. Numerous experiments simulating altitude performance have shown that the indicated horsepower at altitude equals the indicated horsepower at sea level, times the ratio of the corresponding atmospheric pressures, times the square root of the inverse absolute temperature ratio. Or

$$(\text{i.hp.})_a = (\text{i.hp.})_o \left(\frac{P_a}{P_o}\right)\left(\frac{T_o}{T_a}\right)^{\frac{1}{2}}$$

This equation introduces the term "indicated horsepower," which is so designated because it can be measured by an indicator that records pressure within the cylinder in relation to piston stroke. It is nothing more than the power developed within the cylinder before deduction of any mechanical losses. To illustrate the effect of altitude on the indicated horsepower, Figure 2 represents two superimposed indicator cards somewhat idealized and distorted as to compression ratio and supposedly taken at sea level and at an altitude of 15,000 feet. The difference, as will be noted, lies largely in the lower pressure attained by compression of the rarefied air, which, in turn, results in a lower explosion pressure and a smaller work area.

What we are really interested in, however, is the effective or brake horsepower available for transmission to the propeller

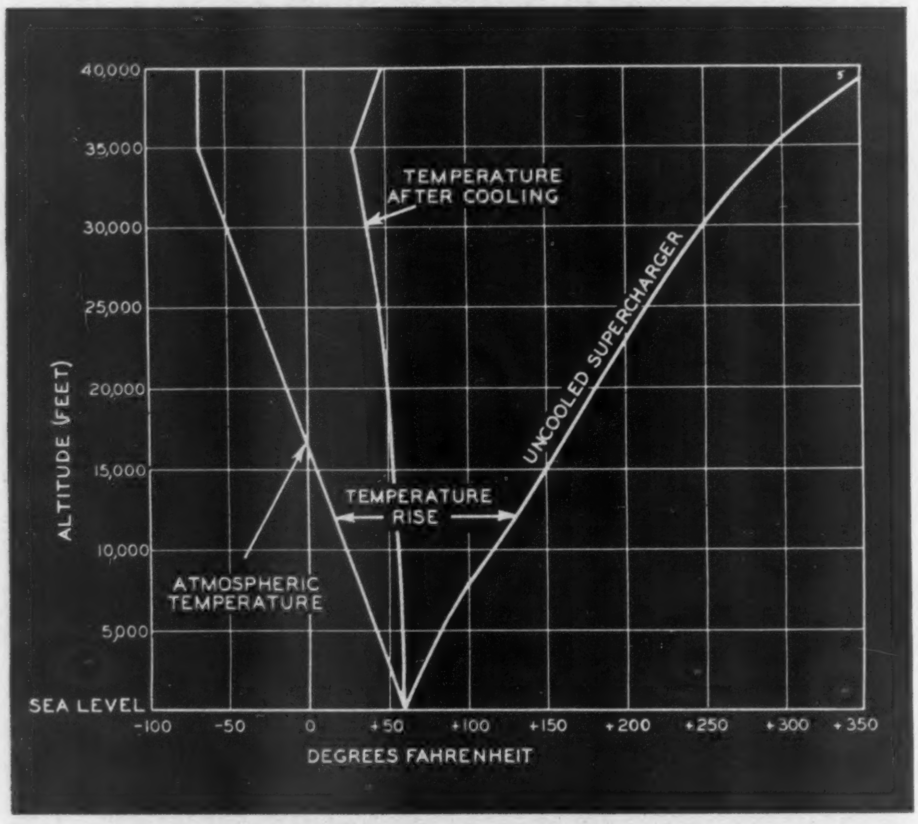



**FIGURE 5**

**The temperature rise during the supercharging operation has an important bearing upon the required pressure ratio. At higher altitudes, temperature rise becomes so great that cooling after supercharging must be resorted to.**

or otherwise usefully applied. The brake horsepower is what is left after deducting from the indicated horsepower all frictional or mechanical losses in the mechanism of the engine. It is usually assumed, and this is supported by tests, that these losses remain practically constant at a given speed, regardless of the load carried by the engine or of the fuel consumed. If, for instance, at a certain altitude, the indicated horsepower has been cut in half, then the frictional losses are still the same, but they now assume twice as much importance and the remaining brake horsepower is appreciably less than half its original value. Therefore, we can see that the brake horsepower of an engine decreases more rapidly with altitude than its indicated horsepower, or than the capacity of the engine to burn fuel. In other words, we find that altitude affects the useful output of an engine even more unfavorably than at first expected.

These general statements can be formulated as follows:

$$(\text{b.hp.})_a = (\text{i.hp.})_o \left(\frac{P_a}{P_o}\right)\left(\frac{T_o}{T_a}\right)^{\frac{1}{2}} - \text{f.hp.}$$

or, brake horsepower at altitude = indicated horsepower corrected for altitude, minus frictional horsepower.

Using this formula, we can now determine the altitude rating in brake horsepower of an unsupercharged engine. The result is shown in Figure 3. It will be noted that the frictional horsepower is herein assumed to be 15 per cent of the indicated horsepower at sea level, which is the same as saying that the mechanical efficiency of the engine is 85 per cent. This probably represents a good enough average, but it is by no means uniformly true, so that the altitude derating curve, as shown, is subject to some small variation one way or the other. The graphical presentation leaves little doubt as to how serious the loss of power of an unsupercharged engine can become at higher altitudes. At 15,000 feet, for instance, the power developed at full throttle has already dropped to one-half that at sea level. To an airplane, this reduction in power would be a severe handicap because it would not only considerably reduce the speed of the craft but would also cut deeply into its climbing rate. In fact, the unsupercharged plane might not even reach that height, depending upon how much excess power it had at sea level. On a stationary engine, the principal effect of the diminished power at this altitude would be to make it relatively twice as expensive. The weight per horsepower would go up in the same proportion as the cost per horsepower—both equally undesirable features.

The question is, therefore, how to prevent this ruinous loss of power at altitude. Theoretically, the answer is quite simple. All that needs to be done is to reëstablish sea-level density of the air in the intake manifold of the engine; or, to put it another way, to see that the same sea-level weight of air be taken into each cylinder during the suction stroke. And the obvious method of accomplishing this is through precompression of the rarefied atmospheric air before it enters the engine cylinders. This is called supercharging, and the compressor that attends to it is called a supercharger. It is evident that supercharging need not be limited to maintaining sea-level density at the cylinder intake. It may well go beyond that, or it may not go so far, and it need not apply to altitude work only. But what happens in such cases is beyond the scope of this survey, and we shall confine ourselves to the function of supercharging as defined in the foregoing.

While supercharging is simple enough in principle, numerous difficulties had to be overcome in order to make it practical. In a plane, weight and space limitations are imposed upon all machinery. This necessitated the development of special compressors. Then, the matter of driving a supercharger offers a number of unusual angles beyond the mechanical problem. One of the requisites for the drive, at least theoretically, is extreme flexibility. For it is clear that at each different altitude a different degree of supercharging is required, or the charging compressor should work with a continuously changing pressure ratio. This, as we shall see, would really mean infinitely variable speed within given limits. It may as well be admitted at once that it is practically impossible to meet this particular requirement in full.

Before enlarging upon this point we shall have to consider what should be the desired pressure ratio at any given altitude. A fact which largely influences this is that air, when compressed, heats up. This counteracts in part the effect of higher pressure upon density. Just how pressure rise and temperature rise are interrelated and how this affects the required degree of compression is developed in detail in an appendix. It will suffice to put down here the resulting formula for required pressure ratio at altitude

$$r = \left(\frac{d_o}{d_a}\right)^n$$

where $r$ is the ratio of the absolute discharge pressure to the absolute intake pressure of the supercharger, $d_o$ is the density at sea level, $d_a$ is the density at any given altitude, and $n$ is the exponent of $V$, the volume, in the equation $PV^n =$ constant, which applies to the change of state of the air during compression. The numerical value of $n$ depends on two factors: first, on how efficient the supercharger is and, second, on whether or not the air is cooled after compression.

Figure 4 has been plotted to show how variations in the $n$ value react upon the required pressure ratio. In effect, this set of curves demonstrates the influence of the compression heat upon the supercharging process. It will be seen, for in-

stance, that in an uncooled supercharger with 75 per cent adiabatic efficiency, the required pressure ratio at an altitude of 21,500 feet is shown to be 3:1. As against this, the perfectly cooled supercharger, or one followed by a perfect aftercooler, would only have to operate with a pressure ratio of about 2:1. But it is obvious that the higher this pressure ratio, the more power the supercharger requires. If this power comes from the engine, the latter is left with less and less net or useful power as the pressure ratio or the value of $r$ goes up. Of even greater importance is the consideration that the design of a supercharger becomes increasingly difficult with higher pressure ratio, and eventually this difficulty sets a limit to the attainable pressure ratio. Complementing this picture, Figure 5 shows the air temperature in the engine inlet manifold for the two practical cases of supercharging taken from Figure 4; that is, for uncooled supercharging with 75 per cent adiabatic efficiency and for supercharging with incomplete though fairly effective aftercooling. The difference between the two temperature curves furnishes further evidence of what has already been stated regarding the effects of compression heat.

We have now reached the point where we can draw several important conclusions. First, the unavoidable temperature rise during compression calls for a greater rate of supercharging than would otherwise be necessary. Second, to reduce the temperature rise and the required pressure ratio, the best possible efficiency of the supercharger is required. Third, above a certain altitude, compression must be followed by cooling in order to keep the pressure ratio of the supercharger within practical limits.

A question which naturally arises at this point is how much the power for supercharging amounts to, compared with the brake horsepower of the engine. A simple way to arrive at the answer, if only approximate, is to calculate the so-called brake mean effective pressure of the charging compressor for the different intake pressures and pressure ratios which, as has previously been seen, apply at various altitudes. If the brake mean effective pressure of the compressor is then corrected in the ratio of compressor intake volume to engine intake volume, or, closely enough, in the ratio of the respective displacements, it becomes directly comparable to the engine brake mean effective pressure. The ratio of the two brake mean effective pressures measures, in percentage of engine brake horsepower, the power required for supercharging. This percentage differs, of course, with the cooled and the uncooled superchargers, as Figure 6 shows. It will be noted that in computing these percentage values the engine brake mean effective pressure was assumed to average 150 pounds per square inch, a figure representing full, sustained engine rating—not to be confused with its so-called take-off rating which is appreciably higher but available for only a few minutes.

By combining the data of Figures 2 and 5, we can now draw the full picture of what altitude supercharging does to the horsepower of the engine. This appears in Figure 7, which brings out the following important point: Although supercharging restores the sea-level brake horsepower of an engine at altitude, this does not assure its complete availability. The net or useful horsepower of the engine, as distinguished from its brake horsepower, is reduced by an appreciable percentage if the supercharger derives its driving power from the engine shaft. The loss in power is roughly twice as large with an uncooled supercharger as it is when cooling is applied. Full engine power at altitude can be maintained only if the supercharger receives its driving power from an independent source, as is the case with a turbine-driven centrifugal supercharger utilizing the exhaust gases of the engine.

## APPENDIX

IT IS common knowledge that air, when compressed, heats up. Anyone who has ever handled a bicycle pump can testify to this fact. The temperature rise during compression is determined by the ratio of final to initial pressure. But it also depends on whether any heat is removed through cooling, and on how much heat is added through friction or from other sources.

When heat is neither added nor subtracted, the compression is said to be adiabatic, and pressure and volume follow the law $PV^k$ = constant, the exponent $k$ having the value 1.4 for dry air. When all the heat of compression is removed as fast as generated we speak of the compression as being isothermal, and pressure and volume maintain the relation $PV$ = constant. Neither method of compression is truly attainable in practice. In an uncooled compressor there are unavoidable frictional and other losses which add to the heat of compression; in a cooled compressor the heat removal is seldom effective enough altogether to prevent a rise in temperature. Hence, compression is usually neither adiabatic nor isothermal; it is of the type called polytropic compression, the term literally meaning "many-kinds-of-heat" compression. Herein pressure and volume maintain the general relation $PV^n$ = constant, where $n$ is now a variable. The value of $n$ is larger than 1.4 when the air absorbs heat during compression, as in an uncooled compressor; it is generally smaller than 1.4 when heat is removed during compression, as in a cooled compressor; and it equals 1.0 for perfect cooling. In effect, adiabatic and isothermal compression are merely two special cases of the more general polytropic change of state.

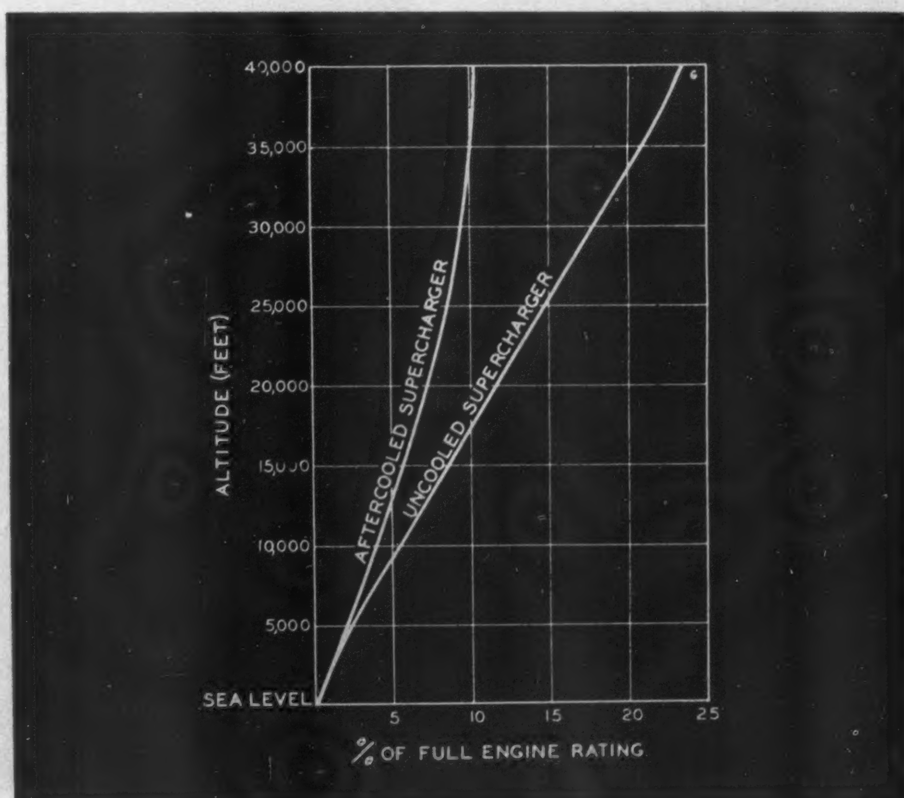



**FIGURE 6**

**Power absorbed by a supercharger in relation to the engine brake horsepower. This becomes appreciable in the case of an uncooled supercharger at higher altitude—another good reason for cooling. Values shown include losses in driving mechanism. These are assumed to be 10 per cent of the supercharger horsepower.**

In polytropic compression the final and initial absolute temperatures $T_2$ and $T_1$ hold the following relation to the respective absolute pressures, $P_2$ and $P_1$:

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}}$$

If we call $T_s$ the absolute temperature after supercharging (and if the supercharger is followed by a cooler this should be the temperature after the cooler), if $T_a$ is the absolute temperature of the atmosphere at altitude, and if the same subscripts are applied to the corresponding absolute pressures, then the above equation reads

$$\frac{T_s}{T_a} = \left(\frac{P_s}{P_a}\right)^{\frac{n-1}{n}}$$

and, if $r$ expresses the pressure ratio,

$$\frac{T_s}{T_a} = r^{\frac{n-1}{n}}$$

or

$$\frac{T_a}{T_s} = \left(\frac{1}{r}\right)^{\frac{n-1}{n}}$$

Now, we have previously seen how density varies with pressure and temperature. Accordingly, if we call $d_s$ the density of the air after supercharging, $d_a$ the density of the air at altitude and before supercharging, then

$$d_s = d_a \frac{P_s}{P_a}\frac{T_a}{T_s} = d_a r \frac{T_a}{T_s}$$

and, by substituting for $\frac{T_a}{T_s}$

$$d_s = d_a r \left(\frac{1}{r}\right)^{\frac{n-1}{n}} = d_a r^{\frac{1}{n}}$$

from which

$$r^{\frac{1}{n}} = \frac{d_s}{d_a}$$

But since supercharging, according to our basic assumption, must reëstablish sea-level density at the engine intake manifold, or $d_s = d_o$, the foregoing equation changes to

$$r^{\frac{1}{n}} = \frac{d_o}{d_a}$$

from which

$$r = \left(\frac{d_o}{d_a}\right)^n$$

This formula furnishes the required ratio of discharge-to-inlet pressure, or the pressure ratio, for the supercharger at any altitude. (It should be noted, incidentally, that this pressure ratio must not be confused with the so-called compression ratio, which compares the volume before compression with that after compression.) Since $n$ is generally greater than $1$, it is clear that the pressure ratio $r$ is greater than the ratio of densities at sea level and at altitude. How much greater depends upon the value of $n$ which, in the case of a supercharger without cooling, again depends upon how efficiently the compression takes place, and in the case of a supercharger with aftercooling, upon how efficient the cooling is.

If compression took place in the uncooled supercharger without heat-producing losses—that is, if the adiabatic compression efficiency were 100 per cent —$n$ would equal 1.4, as has already been noted. But no compressor works as efficiently as that. In the types of compressors used for supercharging it is difficult to realize much better than 75 per cent adiabatic efficiency. (The term adiabatic efficiency stands here for temperature-rise efficiency, which is the ratio of theoretical, adiabatic temperature rise to actually observed temperature rise. Ordinarily, adiabatic efficiency is defined as the ratio of the theoretical, adiabatic compression horsepower to the actual brake horsepower of the compressor. The difference lies in the fact that temperature-rise efficiency does not account for external losses such as bearing friction, leakage, and heat losses through radiation, its value being, therefore, relatively higher.) If we decide on 75 per cent as the adiabatic compression efficiency, then $n$ assumes the value of 1.54.

If, on the other hand, compression is followed by cooling, the efficiency of compression has no bearing on the value of $n$, and all that matters is how nearly the temperature before compression, or the atmospheric temperature, is restored by cooling. If perfect cooling could be achieved, the effect would be equivalent to having isothermal compression, with $n = 1.0$. Since this is practically impossible, the value of $n$ will lie between 1.0 and 1.4, and the more effective the cooling the nearer it will be to 1.0.

If we refer again to the formula for $r$, developed in the foregoing, the ratio of densities may be replaced by that of the respective pressures and temperatures, according to

$$\frac{d_o}{d_a} = \frac{P_o}{P_a}\frac{T_a}{T_o}$$

and this furnishes the more readily computable formula for

$$r = \left(\frac{P_o}{P_a}\frac{T_a}{T_o}\right)^n$$

Values of $r$, determined from this formula for several modes of compression, using $P_a$ and $T_a$ values shown in Figure 1, are plotted in curve form in Figure 4. The assumptions made for $n$ are: (a) $n = 1.0$, or perfect cooling; (b) $n = 1.2$, a case of practically attainable cooling; (c) $n = 1.4$, or perfect compression without cooling; (d) $n = 1.54$, a case of practically attainable compression efficiency and no cooling; (e) $n = 1.69$, poor compression efficiency and no cooling.

**The concluding installment of this article will appear in an early issue.**

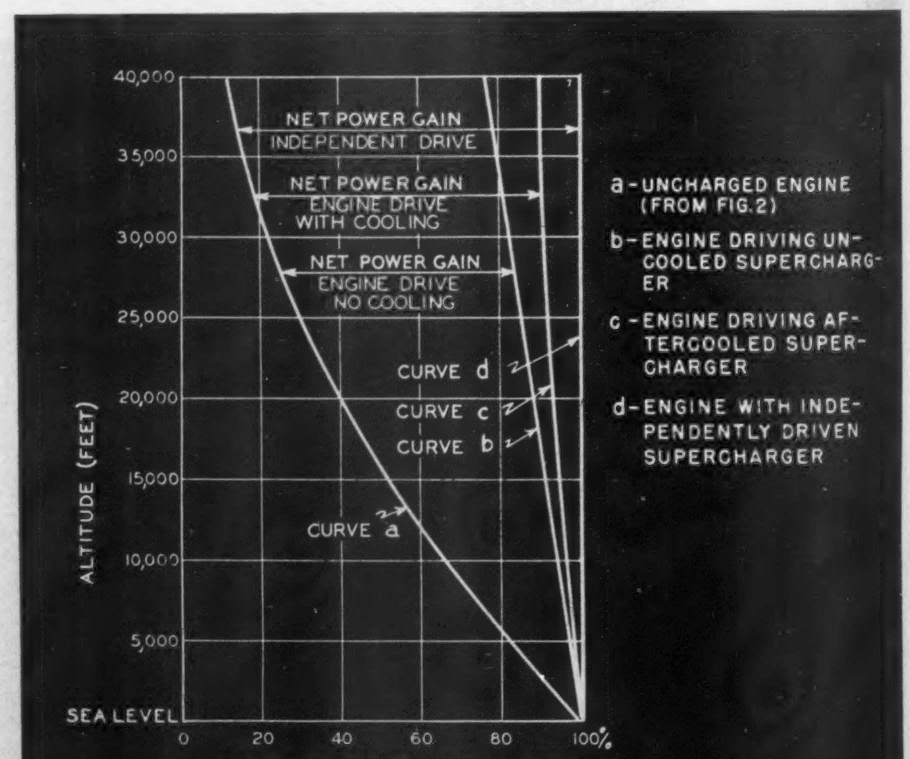
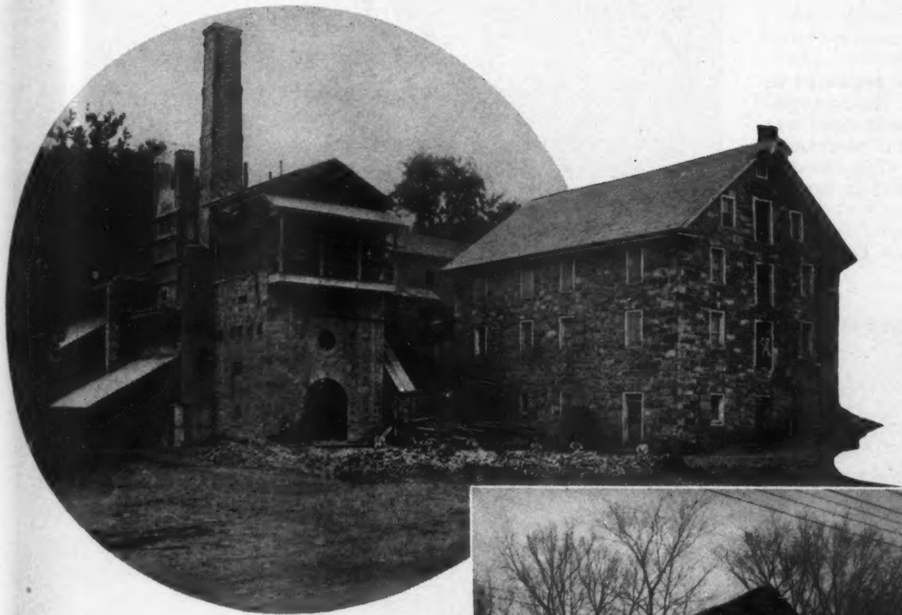



**FIGURE 7**

**Net engine horsepower, without and with supercharging. This shows the advantage of cooling after supercharging and also how drive from the engine shaft cuts down useful, available engine rating. Only an independently driven, or turbosupercharger, can maintain full engine power at all altitudes.**

# The Old Oxford Furnace

A. G. Yount



**YESTERDAY AND TODAY**

The picture at the left was taken sometime in the sixties. Directly above is a later view showing the old Oxford Furnace after the brick superstructure had been added to the engine room. The large stone building on the right in both illustrations was erected in 1813 and served as a grist mill until 1913, when it was converted into the handsome church that is in use today. With the exception of a 20-year period, the furnace was in operation from 1743 until 1884.

THE history of the Oxford Furnace, one of our first producers of iron, might be likened to that of the buried cities of the ancient world—Nineveh, Knossos, and others—of which little was known for centuries until archaeologists unearthed them and revealed their former glory. The furnace dates back to 1741, and it is a fact that little, based on authentic documents, was known about it when it was deeded to the State of New Jersey in 1935 as a monument to American industry.

Much light has been thrown on the enterprise since then through the discovery of a surprising number of records, consisting of deeds, wills, business papers, and even a ledger—the *Joseph Shippen Ledger of Oxford Furnace*. The latter was located in the Congressional Library in Washington, D.C., and covers the works' operations from the beginning to the 1760's. It was placed there by Dr. Lloyd Shippen, a lineal descendant of the Doctors William Shippen of Colonial days. All this confirms the statement of James M. Swank, in his *Iron in All Ages*, that Oxford Furnace "is the second furnace in New Jersey of which there is any exact record, Shrewsbury being the first." In consequence of the wealth of data that has been unearthed, it is now possible to give an authoritative summary of its history, for a complete one would require a small volume, and limited space restricts us to the outstanding facts.

The furnace was erected in 1741-42 by Jonathan Robeson on land owned by Joseph Shippen—both members of prominent Philadelphia families. The first cast was made on March 9, 1743, and with the exception of a period of twenty years, owing to divided ownership, the furnace was active until 1884, when it was finally blown out. To quote Mr. Swank, "It divided with Cornwall Furnace in Pennsylvania the honor of being the oldest furnace in the United States that was then in operation." The original stack was pyramidal in shape. After the first 12 feet for working arches, there was an 8-inch setback for heavy bracing timbers. From that point it rose in 6-foot risers, with setbacks, to its full height of 38 feet. Approximately 25 feet of the original stack is still standing, but about 1860 a strengthening wall was built around it to enable it to withstand the pressure of a powerful hot blast. At that time, production amounted to 60 and more tons of pig iron weekly.

To understand rightly the history of the furnace it is necessary to give a brief account of its various owners. The mines and surface buildings were located on what was known as the Furnace Tract. It covered 578 acres and was part of 1,000 acres of land that had been originally surveyed by Col. Daniel Coxe for three of his sons. The Furnace Tract was assigned to his youngest son, William, from whom it was purchased by Joseph Shippen. The latter contracted with Jonathan Robeson, an experienced ironman of Philadelphia, to erect the furnace and associate struc-

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THE old Oxford Furnace has always played a vital part in the manufacture of munitions for waging our country's wars. Today it lies idle—a reminder of an earlier age in our history. However, the same magnetite deposit which furnished ore for the old iron furnace is being developed today by the Alan Wood Steel Company. Ore reserves have been mapped out in its Washington Mine, where drifts are being driven and a modern mill is being equipped. Operations are scheduled to start in a short time, and once again historic Oxford will serve its country at war.—Editor's Note.

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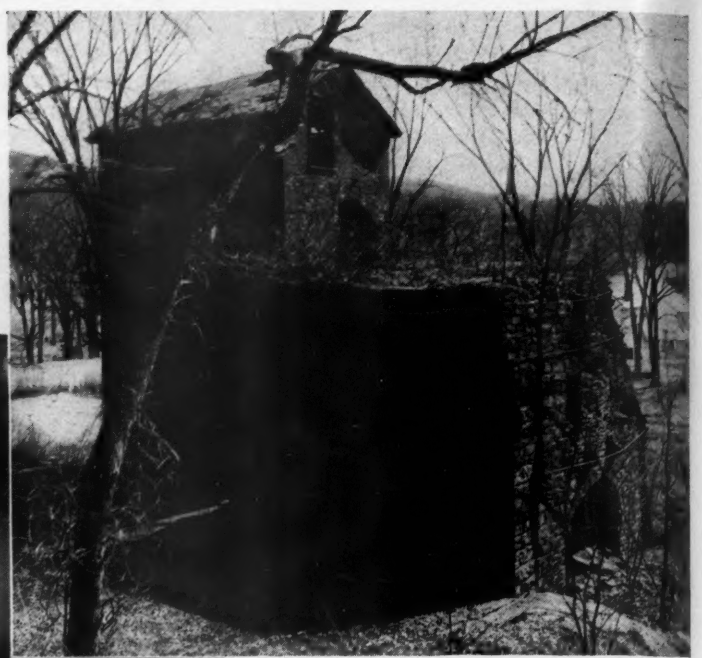
**CASTING ARCH**

**The interior of the old furnace, below, as it appeared in 1888, four years after operations had ceased. The strengthening wall, added in 1860 when the hot-blast method was introduced, can be seen plainly. At the right is an exterior view of the furnace from the smelting end. The blowing engine and associate equipment were housed in the far end of the structure.**



tures, and to divide the profits equally.

In 1745, Robeson bought a one-half interest in the Furnace Tract; but, finding it impossible to acquire the controlling share, sold one-fourth interest to Dr. William Shippen—the younger brother of Joseph—for 1,500 English pounds. This shows how profitable the business was. With the money he built a large forge at Changewater on the Musconetcong River. But in 1754, Joseph and William Shippen decided to erect a large stone house—the Manor House—which is in perfect condition today and is being preserved as a fine example of early Colonial architecture. Robeson was opposed to this because it would take a large part of the profits, and therefore withdrew from the firm. For his holdings in the furnace properties he took in exchange 100 tons of pig iron annually—provided so much was made—for use in his new forge. In 1762, he disposed of his remaining interest in the 5,000 acres of land—and so ended his connection with the Oxford Furnace.

In the years 1765-66, Joseph Shippen sold his share in the furnace properties to his brother William. The former, it should be said, was not a good businessman; he devoted himself to social affairs to such an extent that the family called him "Gentleman Joe." But William, a chemist and noted physician of Philadelphia, was just the opposite in habits, and rapidly became wealthy. He was the sole owner of the furnace and properties from 1766 until his death in 1801. By his holograph will of 1783, which is preserved in the Pennsylvania Museum in Philadelphia, his son, Joseph W., was made sole heir; but when he died in 1795, the properties were divided between his two other children, Dr. William Jr., and Susan Blair.

In 1809, one year after the death of Doctor William, Jr., Mrs. Blair and her heirs sold their half interests to Morris Robeson, grandson of Jonathan, the builder of Oxford Furnace. But as the result of a suit entered in the Sussex County court in 1812, Morris received the buildings, including the Manor House, but not the furnace and the mines. In consequence, the plant lay idle until after Mr. Robeson's death, when, in 1831, his heirs arranged with those of Dr. William, Jr., to lease the properties to the William Henry & Jordan Company. Three years later that concern succeeded in buying out the Shippen heirs, but in 1839 the furnace, with the mines and buildings, again changed hands. George W. and Selden T. Scranton, the purchasers, remained the controlling owners until they failed in 1878, when a new company, the Oxford Iron & Nail Company, took over the business. About 1900, the Empire Steel Company bought the properties and held them under different titles until December, 1941, when all its holdings were acquired by the Alan Wood Steel Company of Conshohocken, Pa.

The Oxford Furnace played an important part in our early history by furnishing munitions for the French and Indian, the Revolutionary, and the Civil wars. The Joseph Shippen Ledger, previously mentioned, contains accounts in the late 1750's running up into the hundreds of pounds (English), showing that the works supplied great quantities of munitions to the Colonial and English armies during the French and Indian Wars. In our fight for independence the furnace also was busy making munitions. Dr. William Shippen, the elder, the sole owner of the furnace during the Revolutionary War, was a great patriot. He was twice elected a member of the Continental Congress; was a trustee and one of the founders of the College of New Jersey (Princeton); and a life-long trustee of the Fourth Presbyterian Church of Philadelphia. His son, Dr. William, Jr., was appointed director general of all Washington's hospitals by Congress. His other son, Joseph, who lived in Oxford and managed the furnace, was paymaster at Washington's hospital in Bethlehem, Pa. Obviously, the owner of the furnace in that period was neither a Tory nor a Quaker, as some writers have stated.

The hot blast eventually used at Oxford in smelting iron ore was invented by J. B. Neilson, at Glasgow, Scotland, in 1828, and in the 1830 bound volume of the *Belvidere Apollo*, a newspaper published in Belvidere, N.J., is the following reference to it under the heading, *Smelting of Iron:* "Heated air for blast furnaces has been used for some time at the Clyde Iron Works in Scotland, and with great success. Experiments have proved that iron is smelted by heated air with three-fourths of the quantity of coals required when cold air, not artificially heated, is employed for

**IRONMASTER'S MANSIONS**

**The Shippen Manor House, below, is one of the oldest dwellings in western New Jersey. It was built in 1754 by Joseph Shippen and is now occupied by C. H. Loux, general manager of the Oxford mining properties of the Alan Wood Steel Company. The walls of this Colonial house are 18 inches thick. At the left is the Mansion House that was constructed in the early sixties by Seldon T. Scranton, president of the Oxford Iron Company and one of the founders of the Scranton, Pa., iron industry. Still a show place in Warren County, it is reputed to have cost $87,000. Walnut woodwork and plate-glass windows add to the beauty of this fine home, which still serves as a residence.**

that purpose, while the product of the furnace in iron is at the same time greatly increased. The furnaces at the Clyde Iron Works are now blown with it. At these works the air before it is thrown into the blast furnaces is heated to 220° Fahrenheit in cast iron vessels placed on furnaces similar to those of steam boilers. It is expected that a higher temperature than 220° will be productive of a proportionally increased effect. But this is a subject of experiment. It is supposed that this improvement will accomplish a saving in the cost of iron in Great Britain to the amount of at least 200,000 pounds per year."

Undoubtedly this information appeared in many papers, for it was read by William Henry, an experienced ironman of Nazareth, Pa. As a result, there was formed the William Henry & Jordan Company, and the old Oxford Furnace, that had been idle for more than two decades, was leased in 1831 for a period of ten years. Mr. Henry moved to Belvidere in 1832 and to Oxford in 1834, and in the latter year had the furnace equipped for hot blast. We shall give the outcome of this improvement in the words of J. M. Swank in *Iron in All Ages*:

"The first practical application of the hot-blast in this country was made at Oxford Furnace, in New Jersey, in 1834, by William Henry, the manager. The waste heat at the tymp passed over the surface of a nest of cast-iron pipes, through which the blast was conveyed to the furnace. The temperature was raised to 250° Fahrenheit, and the product of the furnace was increased by about ten per cent.

"In 1835, a hot-blast oven, containing cast iron arched pipes, was placed in the stack by Mr. Henry, and heated by the flame from the tunnel-head. By this means the temperature was raised to 500°. This innovation in American blast furnace practice increased the product of Oxford Furnace by about forty per-cent, with a saving of the same per cent of fuel. No better device for heating the blast was used in this country until about 1840. Hot-blast ovens, supplied with cast iron arched pipes of various patterns, were in general use in subsequent years down to about 1861."

Mr. Henry never applied for a patent on his "innovation," at least none was issued by our Government. The first patent of the kind was obtained in 1838. Soon after the installation of the hot blast, he turned his attention to anthracite coal—commonly called stone coal in those days—as a substitute for charcoal, until then in common use for smelting iron. Furnaces in Pennsylvania had been experimenting with hard coal, and he believed he could make a success of it. He knew that anthracite and iron ore could be found at Slocum Hollow, at that time the name of what is now Scranton, Pa. To be nearer that place he moved, in 1837, to Stroudsburg, Pa., and in 1839 organized a company and purchased land on which to erect a furnace. But a few months later his chief financial partner, a Mr. Armstrong, died, and his family refused to go on with the plan.

Mr. Henry then started out for Newark, N.J., to find new backers. *En route* he visited his daughter, Mrs. Selden T. Scranton, in Oxford. While there, Mr. Scranton obtained permission from him to try to form a company to take over his contract for the land. The result was the George W. & Selden T. Scranton Company, which also included Sanford Grant and Phillip Mathes, of Easton, Pa., and Belvidere, N. J., respectively. This concern acquired the Slocum Hollow tract. In 1840, G. W. Scranton, with Sanford Grant and some experienced miners and furnacemen from Oxford, began the building of a furnace and buildings there. In two years they were able to operate the works with some success, and then made such rapid strides that they erected a rolling mill in 1845. The following year, both G. W. and S. T. settled in Scranton, leaving their younger brother, Charles, in charge of the Oxford Furnace. However, in 1858, when the Scranton Iron Works had become a great industry, the brothers sold out their interests in it. George was elected to Congress, while Selden returned to Oxford to build up a great iron works there.

That the founding of Scranton was an Oxford enterprise is made certain by the Scranton papers (now in possession of the writer), consisting of hundreds of documents, canceled notes, etc., all dating from 1840 to 1845. Most of them were executed in Oxford, proving that the official business of the Scranton concern


OLD ROLLING MILL

The view at the top shows how the works looked shortly after the Civil War when the rolling mill was completed and a new furnace was added to meet the Oxford Iron Company's increasing demand for pig iron. Both the mill and the furnace were dismantled in 1900 and 1920, respectively. The mix was prepared in the stock house at the right in the picture above and was trammed to the furnace through the covered passageway. When operations were curtailed in 1884, the old stock house served as headquarters for the Republican party. One of its posters is still preserved, as the picture shows.

was initially transacted in Oxford. The notes show from whom the first funds were obtained, for the Scranton brothers were young men without money. However, they were able to borrow large sums solely on account of the successful operations of the Oxford Furnace.

The last 50 years of the Oxford Furnace constituted by far its greatest period. This was made possible by three improvements in the smelting of iron ore. The first was the introduction of the hot blast in 1834-35, which nearly doubled the product made by the use of charcoal, raising the weekly output of pig iron to about 30 tons. The second was the substitution of anthracite coal, which was shipped via the Morris Canal, for charcoal. This started in 1843, increasing production to 38 or 40 tons per week. The third was the installation, in 1856, of a steam engine that, by creating an intensely hot and powerful blast, immediately stepped up the output to 60 tons. Other elements contributed to the rapidly increasing business. One was the making of railway car wheels. This began in the late 1840's, and in 1850 the company erected a large stone casthouse especially for that work. It furnished the Delaware & Lackawanna & Western Railroad with the first car wheels of this type, carting them as far as Scranton.

The concern was given added impetus through the organization of the Oxford Iron Company. This was in 1869 when Selden T. Scranton returned to Oxford for the purpose of building up the iron industry there. He brought with him a large number of expert ironmen and miners, and at once started on his plans for a large rolling mill and nail mill. However, in 1861, the Civil War broke out, and the furnace turned all its facilities to the manufacture of munitions and supplies. This was very profitable, and helped to finance the rolling mill, which was completed soon after the close of the war.

The expansion of the business attracted a rapidly increasing population to the community. This continued for twenty years. In 1843, a standard history stated, "Oxford had a blast furnace, a grist mill and a half-dozen houses." In 1880, it numbered 3,000 inhabitants, and nearly 1,000 men were employed at the iron works. In 1870, the furnace could not produce enough pig iron to meet the requirements of the rolling mill and the nail mill, and a large, new furnace was erected a few hundred yards south of the old one. For about fifteen years both were kept busy smelting iron for the use of the company. The nail mill made more than 200,000 kegs a year, and these were sent everywhere, even around Cape Horn to San Francisco.

Nevertheless, the ebb tide set in with the financial panic in 1874. This resulted in the bankruptcy, in 1878, of the Oxford Iron Company, which was succeeded two years later by the Oxford Iron & Nail Company. About that time were discovered the Lake Superior iron deposits. Because the ore could be scooped up from the surface by steam shovels, it could be produced at lower cost than elsewhere, and it was not long before the mills at Pittsburgh and other western centers were turning out most of the country's iron products. On top of this came the invention of wire nails, which could be made so much more cheaply that the demand for cut nails, like those manufactured in Oxford, fell off rapidly. Consequently, the new furnace could keep the works supplied with iron, and the old one, with its 140 years of faithful service, was finally blown out in the fall of 1884.

Important as the foregoing facts about the Oxford Furnace may be, there are many who will contend that the products made throughout its long period of operation are its chief claim to a conspicuous place in the history of American industry. In their varied character, as well as in their quantity, these products far exceeded those of any other old furnace of the same size in the country. In Colonial days, the settlers had to have iron implements of various kinds for farming and other purposes, and these were made in

local forges and blacksmith shops, of which there were many. As the forges were dependent upon the few furnaces of the region for their pig iron, the latter had a large market for their output. The excess, in the case of Oxford Furnace, was at that time carted to Foul Rift, on the Delaware River, about 8 miles distant, where the company owned a landing place and a ferry. There the material was loaded on to Durham boats and shipped to Philadelphia and other points along the river.

The Oxford Furnace also operated a forge and smithies to make bar and tire iron, nails, etc. Besides, there was a casthouse where all kinds of castings needed by the colonists were produced. The most interesting of these were chimney backs for fireplaces, for which there was great demand. Since most of them were made in the reign of King George II, they usually bore the royal arms in relief and his title. Many of these chimney backs are to be found in museums and private homes, where they are valued possessions. What is perhaps the largest in existence, taken in 1876 from the Shippen Manor House in Oxford, is in the Pennsylvania Museum in Philadelphia. The name "Oxford" and the date "1754" appear in the lower corners. It may be stated that pig iron, cannon balls, and at least one mortar shell of the Colonial period are in various Oxford and neighboring homes; and in all probability these relics will find a place in the Oxford Furnace Museum in the near future.

**HEADFRAME**

Although idle for several years, the Washington Mine of the Alan Wood Steel Company is now being made ready for its part in the war program. It is this same magnetite deposit that furnished ore for the old Oxford Furnace as early as the French and Indian Wars.

Now we come to the greatest period in the history of the furnace—the years from 1834 to 1884. In addition to pig iron for forges and smithies, for which there was a widespread and big demand, the chief work was the casting of stoves, which had by that time come into general use. In the 1840's, according to the Scranton papers, orders for bar and tire iron, as well as for pig iron, came from distant places in Pennsylvania and New Jersey, especially from Paterson and Boonton. Large quantities were also sent to New York City. Ten years later the furnace specialized in making railroad car wheels, as previously stated. After the Civil War, it was producing 60 and more tons of pig iron weekly to supply material for the great rolling mill and nail mill alongside the foundry, as well as for other works. Thus, both for the service it rendered the nation in days of strife and, most of all, the American people throughout its long, active life, the Oxford Furnace deserves a high place as a monument to industry.

In 1935 the writer called the attention of the New Jersey State Commission on Historic Sites to the merits of the furnace, of which little was then known. After making an examination, the Commission gladly accepted it by deed from the Warren Pipe & Foundry Corporation of Phillipsburg, N. J. Furthermore, that body had an account of it, with illustrations, prepared for the *New York Times*, which closed with the statement that New Jersey had taken over the Oxford Furnace to be "Restored as the only historic industrial plant owned and preserved by the State of New Jersey. Old military headquarters, inns, mansions, and birthplaces publicly owned and maintained, dot New Jersey from the Delaware River to the Hudson. The Furnace, however, will be unique. It will be a memorial to the rise and development of American Industry."

The foregoing was quoted in the *Journal of the Institute of Mining and Metallurgical Engineers* with the editorial comment: "It is to be hoped that the idea will spread. Even with all that Henry Ford has done, too large a proportion of the historic shrines of the country are still of military significance. . . . How much better it would be if such grim souvenirs were . . . . displaced by some evidence of social and industrial progress such as this old blast furnace of course will be."

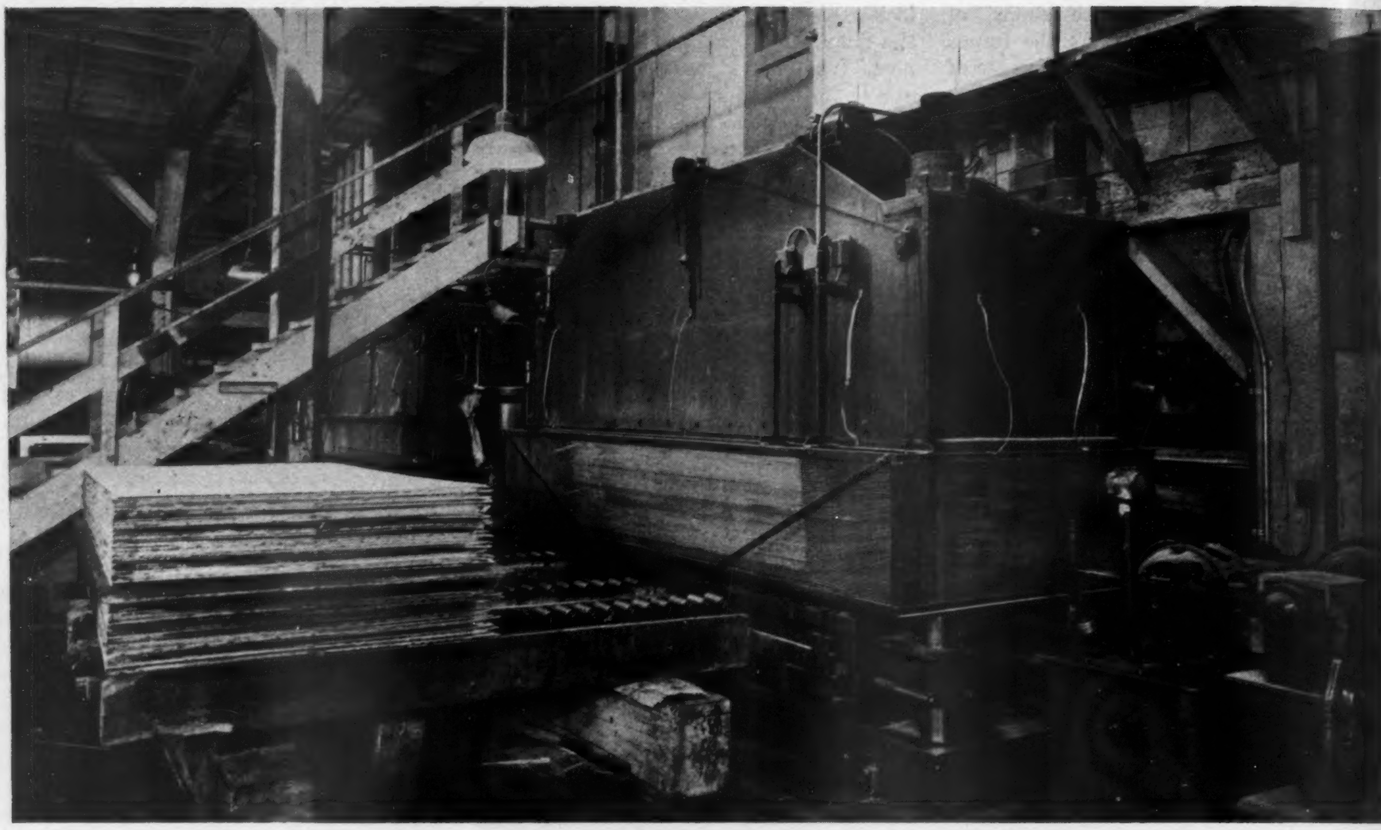
The decade following the closing of the old furnace was marked by earnest efforts


**NAIL-KEG HEAD**

One of the most popular products of the historic furnace was cut nails of which as many as 200,000 kegs were produced in a year. As the legend on the cover plainly shows, the keg of which this top formed a part came from the Oxford Iron & Nail Company, which succeeded the Oxford Iron Company in 1880. There was a big market for the nails, and they were even shipped around Cape Horn to San Francisco.

of the Oxford Iron & Nail Company to make the business profitable. The new furnace, now equipped with a powerful blower, increased its daily output of iron to more than 125 tons. All the resources of the firm were put to work, and normally everything would have been well. But competition offered by the great iron works of Pittsburgh and elsewhere, together with the hard times of the 1890's, turned their deserved profits into losses and necessitated a shutdown in 1895. A few years later the properties were purchased by the Empire Iron & Steel Company, which operated the furnace successfully until 1921 largely because of the first World War, when it furnished large quantities of iron for the manufacture of munitions. In the 1920's ownership was vested in the Warren Foundry & Pipe Corporation, which proceeded to dismantle the new furnace in the belief that the day of iron works in Oxford was over.

In 1929 the properties were leased to the Alan Wood Steel Company, and ore was shipped from the mines for some time. But the company gave more attention to the development of the iron-ore resources and carried out tunneling and drilling operations at low levels. At the outbreak of the second World War, mining was resumed and several hundred thousand tons of ore were sent to its steel plant in Conshohocken. In December of 1941 the company purchased the Oxford properties, along with others in New Jersey. Now, new machinery is being installed at Oxford, and the indications are that the mines will soon be producing more iron ore than they did at any time during the 200-odd years in which they have been worked.



**A PRESS IN OPERATION**

A stack of plywood sheets is undergoing consolidation and drying inside the protective wire netting while another at the left is ready for the press. The dark-colored layer in the middle of the latter pile is the positive plate in the unique electrical condenser that dries the glue in a few minutes. Current is introduced at that level and flows both upward and downward to the top and bottom members of the press which serve as negative plates. This arrangement eliminates insulation problems and permits using practically standard hydraulic-press equipment.

# High-Frequency Current Speeds Plywood Manufacture

*Henry W. Young*

IN THE May, 1941, issue of this magazine was published an article, under the title of *Wood Sandwiches*, which told of the manufacture of plywood—how the choicest specimens of the American Douglas Fir are "unwound" into thin sheets, and how these are cut, glued, pressed, dried, and finished into panels that have been referred to as the "Modern miracle in wood—pound for pound stronger than steel."

Since that time a radically new development has appeared in connection with one stage of production—that in which the sheets or plies, after the glue has been applied, are pressed together and the adhesive is set to form a bond stronger even than the wood itself. It is an electrical process, and to the layman a mystifying one. He may be forgiven if he speaks of it somewhat erroneously as a "kind of radio process," inasmuch as it makes use of radio-frequency current of 2,000,000 cycles per second and the equipment embodies mercury-vapor rectifying and amplifying tubes that are similar to but have ten times the capacity of those used in the most powerful radio transmission stations today. Or, he may refer to it as an electrotherapy process and not be far off, for it does, in fact, produce heat—an internal "fever"—deep in the tissues of the wood.

Extensive experiments along this general line were made by Paul D. Zottu, electrical and radio engineer associated with The Girdler Corporation, Louisville, Ky. Officials of the M & M Wood Working Company, Portland, Oreg., including Michael Pasquier, chief engineer, watched the research work carefully and came to the conclusion that the principle could be applied to the generation of heat necessary to set the glue quickly while the panels are being pressed. The upshot was that two new presses featuring the high-frequency electrical equipment were ordered. Nothing like them has ever been employed before in the plywood industry. Installed late in 1941, the machines are now handling, with marked economy, the total output of the plant operated by the Albany Plylock Division of the M & M Company.

There is nothing radically new in the machine itself, which is of the hydraulic type using oil. The novelty lies in its operation, which is based on the principle of the static electrical condenser which, in this case, is built up as follows: First comes the negative plate or metallic base of the press. On this is stacked a bundle of plywood panels, with the wet glue between the sheets, which is the insulating medium or the dielectric. This is followed by the positive plate, which consists of a metal-plated wooden caul board. On this is placed another stack of panels or dielectric, and, finally, there is the top of the press, which constitutes another negative plate.

Now, if this odd condenser were to be employed for the purpose for which units

of this type are normally intended, it would be an extremely inefficient one. The moist plywood, with the moister glue between the plies, is but an indifferent insulating medium. This is contrary to what we look for in a condenser. For the latter, a dielectric is sought that, unless overloaded to the point where a puncturing spark occurs, will prevent the flow of electrical energy from plate to plate. In other words, its function is to accumulate a charge of electricity. But for the application in question, what might be called a leaky dielectric was wanted, one that would permit a certain amount of electricity to flow from the positive plate through the dielectric to the negative plate, and the wet plywood is just such a medium.

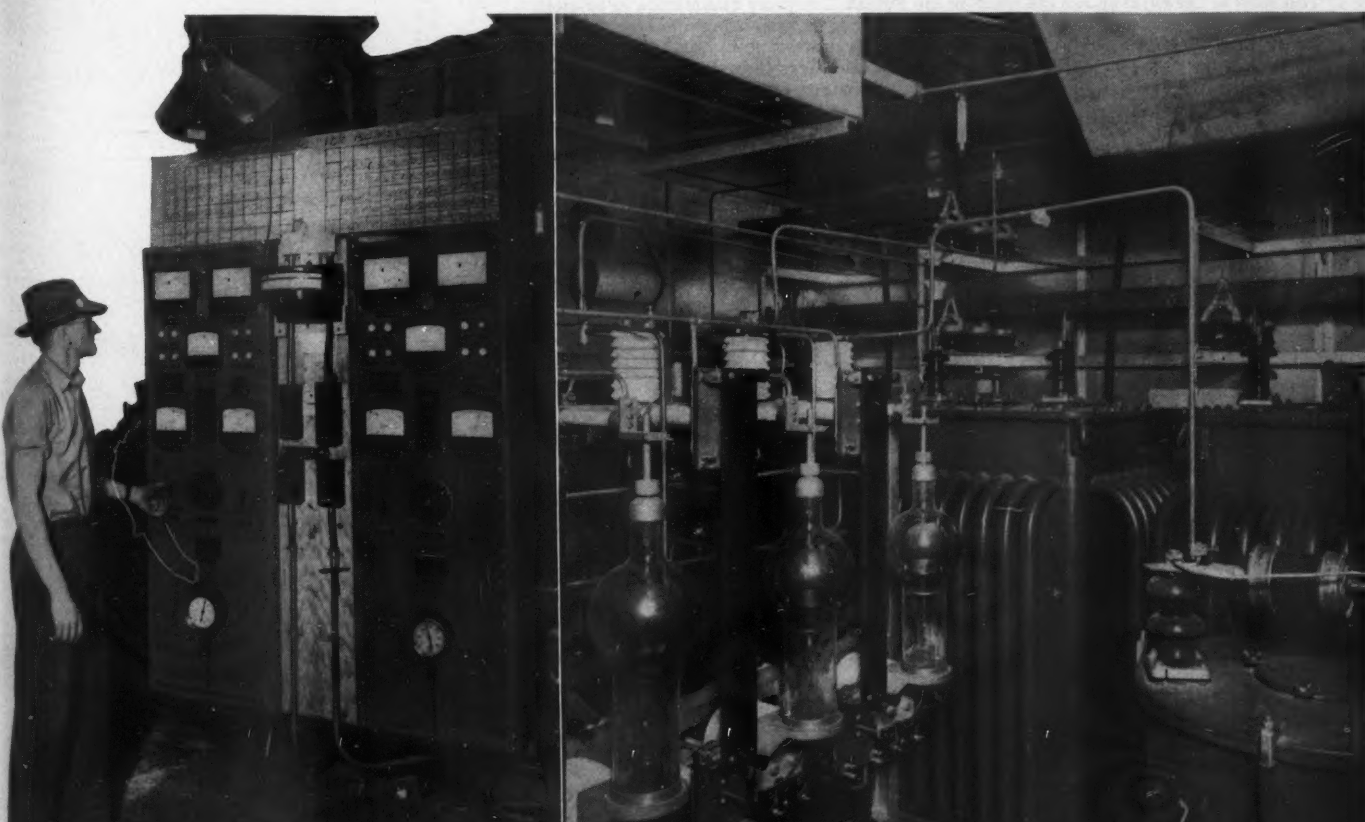
The passage of the high-frequency current through the wood distorts or rearranges the molecules at every impulse. At a frequency of 2,000,000 cycles per second, the result is molecular friction which manifests itself in the form of heat released through the entire mass of the dielectric. So there you have it. A very inefficient type of electrical condenser becomes a highly efficient heater that sets the glue throughout the whole plywood bundle in a few minutes.

In order to appreciate the advantages of the high-frequency method, it is necessary briefly to explain how plywood is commonly made. In the case of the hot press, the panels are formed individually between two steel plates heated by live steam. This procedure is slower because the heat is applied first to the surface and then, at a reduced degree, to the inner plies or core. This may result in charring, surface checking, or blistering—in short, in a higher percentage of imperfect panels —by reason of the formation of steam pockets. By the high-frequency method the heat is distributed uniformly throughout the mass and is ordinarily kept under control at 160 to 180°F. Sometimes, however, it reaches a maximum of 300°, depending on the glue employed. Furthermore, panels can be made up to 9 inches thick. With the hot press the practical limit is about 1 inch.

In the manufacture of plywood by cold-pressing, a stack of panels is put in the press between top and bottom caul boards. After pressure has been applied, the stack is held tight together by means of metal bars and turnbuckles and is then put aside for the glue to set. This is usually an overnight process. Considering only time, labor, and floor space involved, this method obviously cannot compete with the new one which presses a large number of panels, ready for finishing, in one operation that takes not more than a few minutes.

Current for the work is furnished by the company's steam power plant at 4,400 volts. It is stepped up by transformers to 15,000 volts; converted to direct current by means of mercury-arc rectifiers; and, finally, again converted to current of radio-frequency by other mercury-vapor tubes of large capacity. The power delivered at the transformers is of 600 kw., as compared with 50 kw. used by high-power radio transmitting stations.

The system of electric control employed is too intricate to explain in a nontechnical article. Suffice it to say that the capacity of the condenser—represented by the plywood and press—and that of the equipment is at all times balanced, thus regulating the flow of electricity through the dielectric (the plywood) and maintaining the temperature at the desired point, regardless of the size and shape of the bundle. Narrower and shorter stacks can be handled without appreciable loss in rate of production because the heat applied is nearly in direct proportion to the volume of the plywood in the press.

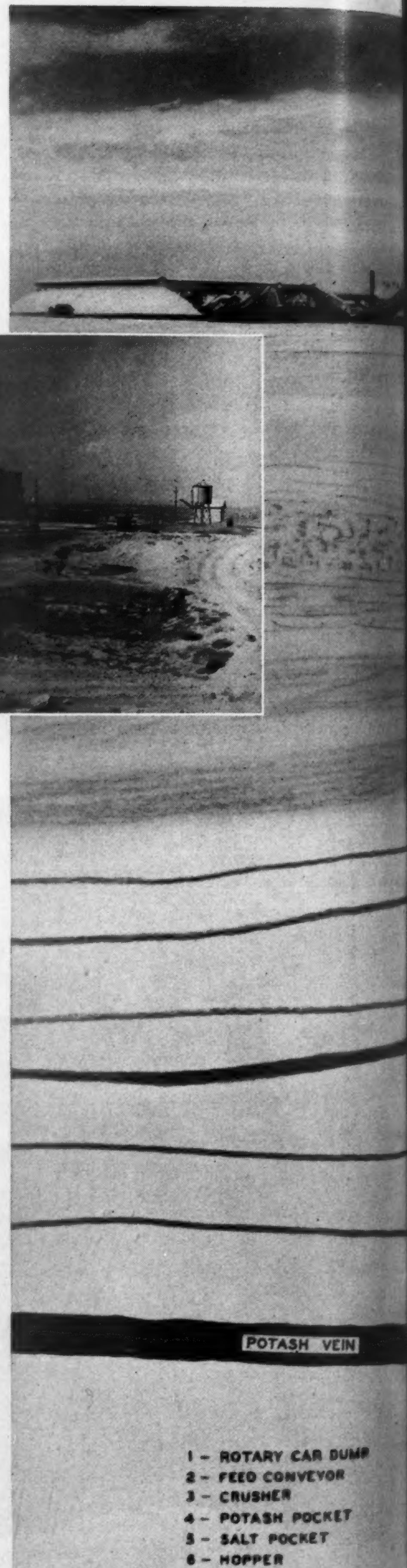


**CONTROL BOARD AND CONVERTING EQUIPMENT**

At the left is the automatic control board which looks like but differs considerably from an ordinary switchboard. The other picture shows part of the plant used to transform alternating current at 4,400 volts to 15,000 volts and to convert it to radio-frequency current of 2,000,000 cycles per second. The operation of the two plywood presses requires 600 kw. The converting equipment is housed in a room over the presses.

# Potash—Plant Food and Chemical Tool Box

*Fremont Kutnewsky*




**PLANTS AND POTASH MINE**

The view at the right shows the plant of the Potash Company of America in relation to the potash vein and how the mineral is brought to the surface. The deposit is from 12 to 14 feet thick and is interposed between strata of salt. Immediately above is the refinery of the United States Potash Company. Together with the International Minerals & Chemical Corporation, these plants are operating in the Carlsbad, N. Mex., area on Government-leased land and under Government supervision. They are supplying all our present potash needs.

ALTHOUGH we have always considered America a land of plenty, the two wars of the past quarter-century have proved that we are not entirely self-sufficient. Today we lack several important materials, especially rubber. In 1914 it was potash and dyestuffs. The ability to find ways out of economic cul-de-sacs has always been a characteristic of the American people. At the present time, extensive plans are being made for the production of synthetic rubber, and substantial quantities of it have already been manufactured. In due time, no doubt, we shall be virtually independent of foreign sources of rubber. Our experience with potash since the last war is an excellent precedent for this confidence.

As mentioned previously, the first World War found us in an embarrassing predicament, for our supplies of potash and dyes were practically cut off. It wasn't so bad getting along without certain colors in cloth and paper, and using 2-cent stamps with a washed-out look, but the shortage of potash hit us where it hurt. Farmers were pressed to increase production under the slogan "Food Will Win the War," and that called for more, not less, potash fertilizer in the soil. Housewives soon found that potatoes turned dark and soggy while cooking. Smokers began to get tobacco that burned hot instead of cool and free. Cotton growers had trouble with "rust," and their crops declined. Fruits and vegetables were not what they had been. All these evils were attributable to a lack of potash. We Americans awoke uncomfortably to the fact that the Germans, our enemies, had acquired an artificial but tight control over our important agricultural and textile industries. For 40 years they had taught us to use potash, and they were in a position to furnish it in the amount to which we had become accustomed. France also was supplying us with potash fertilizers prior to the first World War.

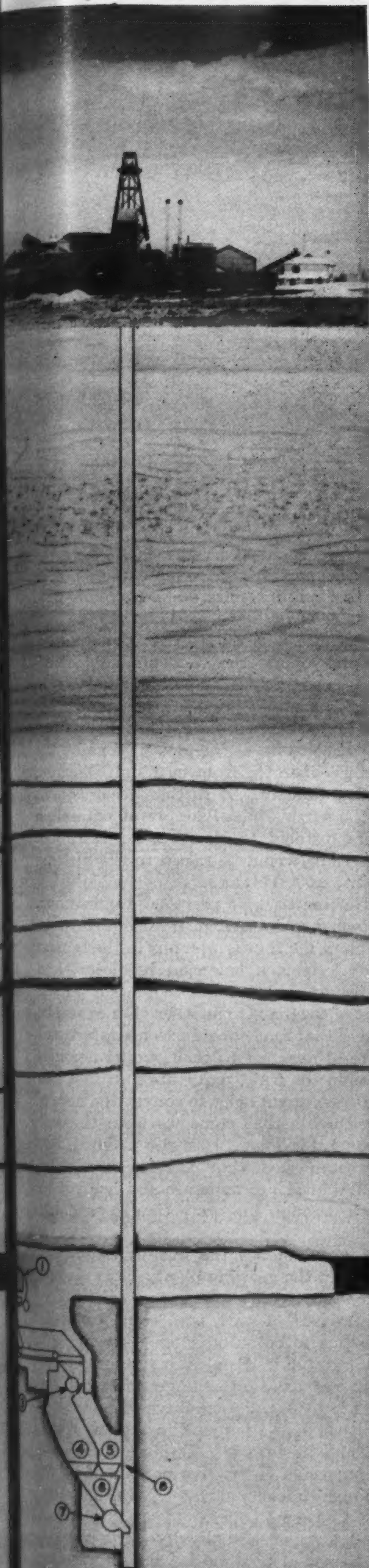
How the United States came up from behind and made itself independent of foreign supplies of both potash and dyestuffs is a story for the book of American enterprise. The development of a potash industry of our own has done much to solve our chemical problems and has, at the same time, made fertilizers as plentiful as corn and wheat. Potash compounds are used in the manufacture of dyestuffs and a thousand other industrial products, including fine optical glass, medicines, explosives, and synthetics. They are playing a vital role today in making America the arsenal of the democracies, the breadbasket of the United Nations, and the

most powerful military force the world has ever seen.

Generally speaking, "potash" refers to the salts of potassium, one of the commonest being potassium chloride, first cousin to common salt. To the chemist the two salts are much akin, as indicated by their chemical designations: potassium chloride and sodium chloride. Potassium and sodium are alkali metals, two of the lightest known to man. Neither is found free in nature, but always tied up with some stabilizing partner, frequently chlorine. Both have such an affinity for oxygen that they combine with it on contact, whether in air or in water. In water they go berserk, and sizzle and spit as they swim angrily around like drops of molten metal. They completely disappear, forming hydroxides. In other words, they have combined with oxygen and hydrogen. Keep the hydrogen out and you have potassium oxide, which is what chemists mean when they use the word "potash." Fertilizer men call it $K_2O$, and commonly use this symbol as a unit of measurement in their industry.

Strictly speaking, we ought to say "potassium" when we refer to the metal itself, and "potash" when we mean potassium carbonate or one of the potassium salts or compounds. The word was originally hyphenated, "pot-ash," and referred to the ash left by burning plant material in iron pots. The naked metal is seldom seen outside of the laboratory, where it has to be kept under kerosene or naphtha. In the open, it immediately absorbs oxygen from the air. A salt, roughly speaking, is a product of the marriage of an alkali metal and an acid. These two are always forming compounds, even in our bodies, where they account for body chemistry. Potassium and sulphuric acid, for example, come out of the wedding ceremony as potassium sulfate.

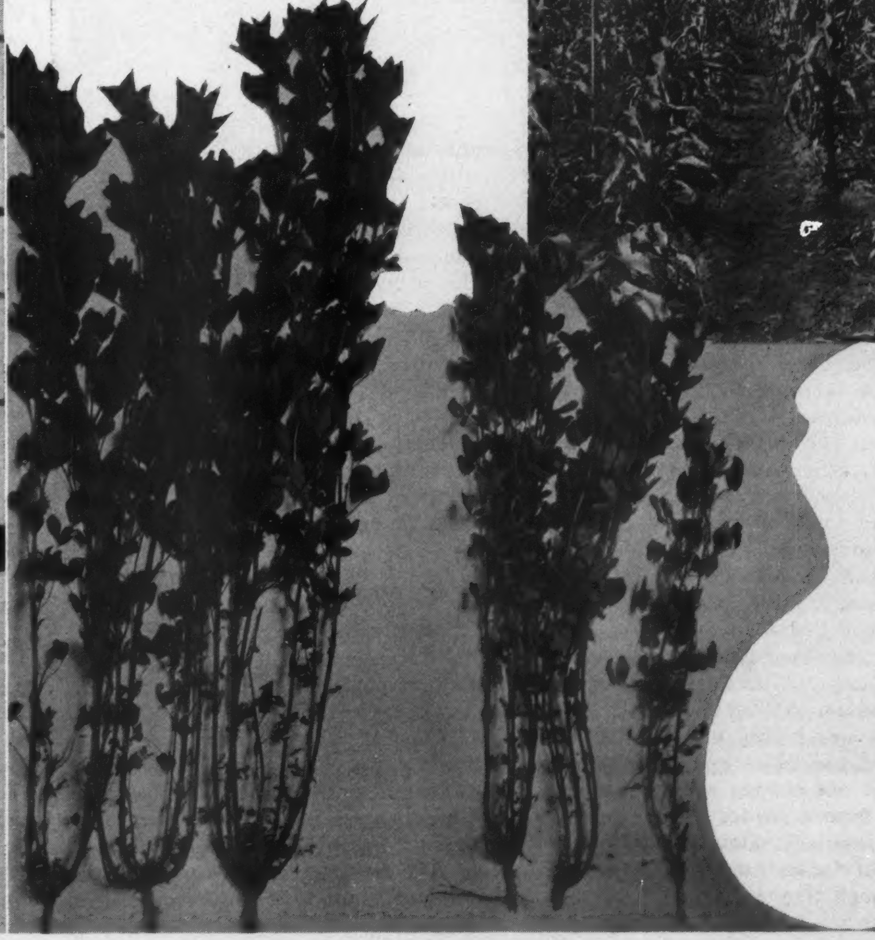
Potassium is one of the 92 elements which chemists say compose the earth and all that's in it, on it, and around it. An element is something they can't crack, break down, and take something else out of by any ordinary means. It is the irreducible substance. Neither animal nor plant life can exist without potassium. It is one of the fourteen elements that are absolutely essential to life. Fortunately, it



**WITH AND WITHOUT**

These pictures of comparative stands of corn and of alfalfa plants tell their own story. The hardy, tall plants were grown in soil well fertilized with potash.

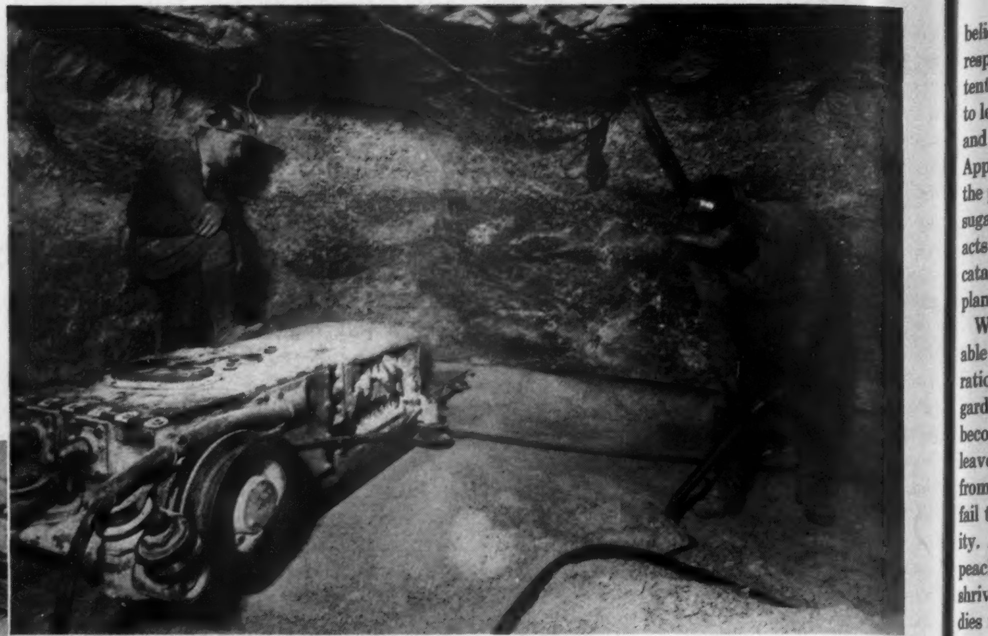

Photos, American Potash Institute, Inc.



## UNDERGROUND OPERATIONS

Mining is done by the room-and-pillar method by the aid of large machines such as the one shown at the right. It makes a cut 8½ feet deep across the working face at a rate of 5 inches a minute. Rows of 1⅝-inch holes of the same depth as the undercut are then drilled in the face, and the blasted material is loaded directly into cars by scraper-type (below) or conveyor loaders. The scraper is box-shaped and, when well filled, can handle 1¼ tons of potash.

Photos, Potash Company of America



is one of the most plentiful substances found in the earth's crust, of which it forms about 2½ per cent. Yet, a great part of the potassium in nature is locked up in compounds in such a way that neither the roots of plants nor ingenious man can profitably get at it. Plants take potassium from the soil faster than they remove most other elements, and that is why it must be returned to the soil in the form of fertilizer. During our pioneering days, if a man's land "played out" he simply moved farther west into new country. Today he stays where he is and fertilizes.

Here are some of the ways in which potash affects us in everyday life: Adequate potash in the soil means thick-skinned, heavy, juicy oranges and grapefruit and sweet canteloupes for breakfast. Whenever you enjoy meaty, highly colored tomatoes, crisp lettuce or celery, or firm watermelon for your lunch you may be sure there was plenty of potash in the garden. If you like tender and luscious vegetables, not stringy and tough ones, get them from a grower who knows and respects his potash. Housewives know all the signs of "potash starvation" in fresh foods, though they may not call it that. In order to sell to first-rate markets, the farmer must have potash in his soil. An evening smoke of mild and free-burning tobacco, and a healthy green lawn full of clover will never be yours if the soils in which they grow are hungry for potash.

But plant life is not the only thing that is benefited by potash. Those crystal-clear, delicately shaded refractive glasses that you wear for eye comfort and easy vision are brilliant and weather-resistant because one of their constituents is potash. The clean, sharp photographs, the enlargements unmarred by "grain," the lithographed calendar on your wall, and the popular picture magazine printed on offset presses are all possible because of potash. As long as we have automobile traffic you will continue to be stopped at intersections by sharp, ruby-red lights. They're usually made of red selenium glass containing potash. Other everyday items that owe their existence to potash include safety matches, blueprints, Javel water, gunpowder and blasting powder, electroplates, textile prints, insecticides, bleaches, deodorants, gas masks, and synthetic perfumes. The biggest share of industrial potash, however, goes into soaps and glass. Sodium compounds are used in some of these products, usually when they are of the cheaper variety. In many cases potash gives superior results, and is therefore used in spite of its higher cost.

Because it is radioactive, potassium is unique among the elements now considered necessary to sustain life. The U.S. Department of Agriculture points out that the temperature of the earth is maintained about constant at the present time by the energy liberated from uranium, thorium, and potassium. It further declares that if the earth's initial supply of potassium were restored to it, the temperature of our globe would be raised to the melting point, 1,000°C. (1,832°F.).

Getting back to practical applications, potash has somewhat the same relation to plant life that lymph has to the human body. It is a balancer, regulator, and transporter of useful ingredients from one part of the plant to another. For example, it sees that food substances manufactured in the leaves get to their proper destinations in the fruit, root, tuber, or boll. In the same way it helps to convey the mineral elements that come up from the soil through the roots. It is also claimed, but not established, that potash controls the plant's intake of moisture and helps it to retain enough for protection during dry spells.

Yet, while it's the busiest bundle of atoms in the growing plant, potash is not taken into the fabric or framework itself—it's no part of seed, leaf, stem, or fruit. It seems to be an outsider—present, but not a part of it. Some of it runs down the stalk and back into the ground when its work is done, and some stays with the ship till it sinks and is found in the ash when the hulk is burned. It is said that an average man is "twelve pounds of ashes and eight buckets of water." In the ashes would be some potash.

What potash actually does for a plant is not so well understood as what happens to one that doesn't have enough of it. It is

believed to influence the plant's rate of respiration, to control the chlorophyll content of its leaves, to help it resist drought, to lessen injuries due to low temperatures, and to bolster its resistance to disease. Apparently, potash takes especial care of the processing and storage of starches and sugars in plant life. All in all, the fertilizer acts as a sort of self-starting, automatic catalyst in the manufacture of a growing plant out of air, water, sunshine, and soil.

What happens when potash is not available in the soil to give crops a balanced ration is now pretty well known to farmers, gardners, and orchardists. Tobacco leaves become spotty and parts drop out, and the leaves are reduced in size. Cotton suffers from "rust," its leaves mottle, many bolls fail to open, and the fiber is of poor quality. Apple trees show signs called "scorch," peaches are dwarfed, cereal crops have shriveled grains, the foliage of root crops dies too soon to permit maximum storage of sugar and starches in the roots. Quantity is reduced—keeping-quality is impaired.

In order for potash to do its work of arranging, storing, and regulating, the other thirteen essential elements also have to be present in sufficient quantity. "Plants may obtain hydrogen, oxygen, carbon, and to some extent nitrogen from air and water," says F. S. Lodge of the National Fertilizer Association. "The other necessary plant foods must be furnished by the soil. Some are needed in minute quantities, and are mostly present in adequate amounts. Nitrogen, phosphorus, and potassium are the three elements most often insufficient in soils to produce optimum crops. Consequently, they are the elements added in commercial fertilizers." Certain plants remove potash from the soil more rapidly, others nitrogen. Sometimes the locked-up surplus already in the soil is freed by chemical reaction of other elements, adding to the available potash. The amount varies with the particular soil, and this is the reason for soil-testing by careful agriculturists.

As an example of the rate at which plant life draws potash from the soil take corn, of which 100 bushels on one acre will absorb 125 pounds. This is equal to three 100-pound bags of commercial muriate of potash. "Muriate of potash" is what commercial fertilizer men call potassium chloride—potash to us. Thus, corn needs more than a pound per bushel. Potatoes require about the same replacement. Four tons of alfalfa will remove 178 pounds of potash. As much as 200 pounds per acre is added in some potato fields in Maine and tobacco fields in the Connecticut Valley. Since these fertilizers cost money, it is reasonable to assume that not every tiller of the soil is conscientious enough to apply them in sufficient amounts.

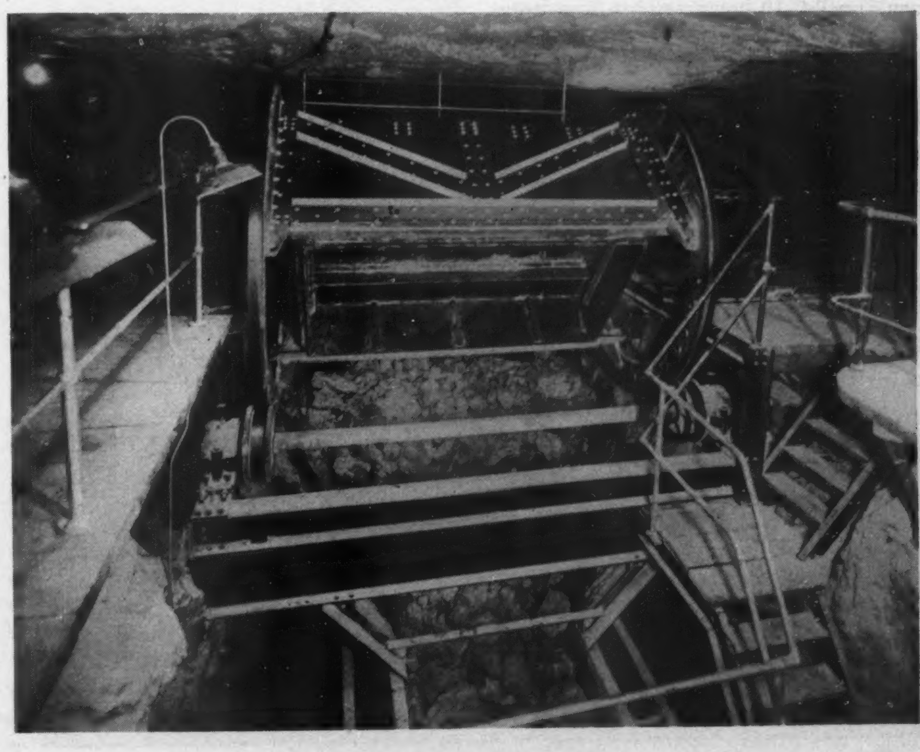
Mr. Lodge estimates that United States' crops normally take 3,500,000 tons of potash from the soil each year. This would naturally be stepped up in time of war when our fields have to supply not only ourselves but our allies. In 1938, all but one of the 48 states required that fertilizers be offered for sale on the basis of guaranteed plant-food content of nitrogen, phosphoric acid, or potash—or a combination of two or more. Possibly by this time the other state has made it unanimous.

"The wealth of Rome passed into poverty, the organization into disintegration, the power and pride into decadence and apathy." So Will Durant, in his *Story of Philosophy*, epitomizes the sad fate of an empire. In passing, he also notes the curious fact that Lucretius, a Roman poet of the first century A.D., attributed the decay of agriculture in his country to exhaustion of the soil. Very possibly this could have been due to potash starvation. Nearly 2,000 years later, men were finally to discover ways and means of restoring fertility to poor soils. Modern agriculture began in 1840 when Baron Justus von Liebig established the fact that growing crops remove potash from the soil. Since potash is essential to plant life, he said, and is taken from the soil by growing crops, it must be returned.

For some time the Germans had been mining common salt near Stassfurt and had been throwing away a companion mineral which they called "bitter salts." Their intensive search for something that would enable them to cash in on this waste product led to Liebig's experiments and discovery. He laid the groundwork for scientific farming and agricultural colleges. The "bitter salts" were potash. By 1870, world-minded German businessmen had embarked upon a great international potash selling campaign. They persuaded farmers in other countries to feed their soils with potash to keep them fertile and productive. They set up a world monopoly in fertilizers that held tight until the time of the first World War. America and other agrarian countries learned to use potash, to need it, and to buy it from the Germans.

The fruitfulness of the Americas was one of the wonders of the world. As long as there was virgin land farther west, people didn't pay much attention to the problem of depleted soils. However, George Washington and Benjamin Franklin understood that cultivated land may become less fertile. Franklin conducted experiments in soil-feeding on some property he owned in New Jersey. In order to prove to his neighbors that lime was good for the soil, he placed on the piece of ground a huge inscription, forming the letters with plaster. It read: "This field has been plastered." When the crop came up, a more vigorous growth marked the letters so that they could be read at a considerable distance.

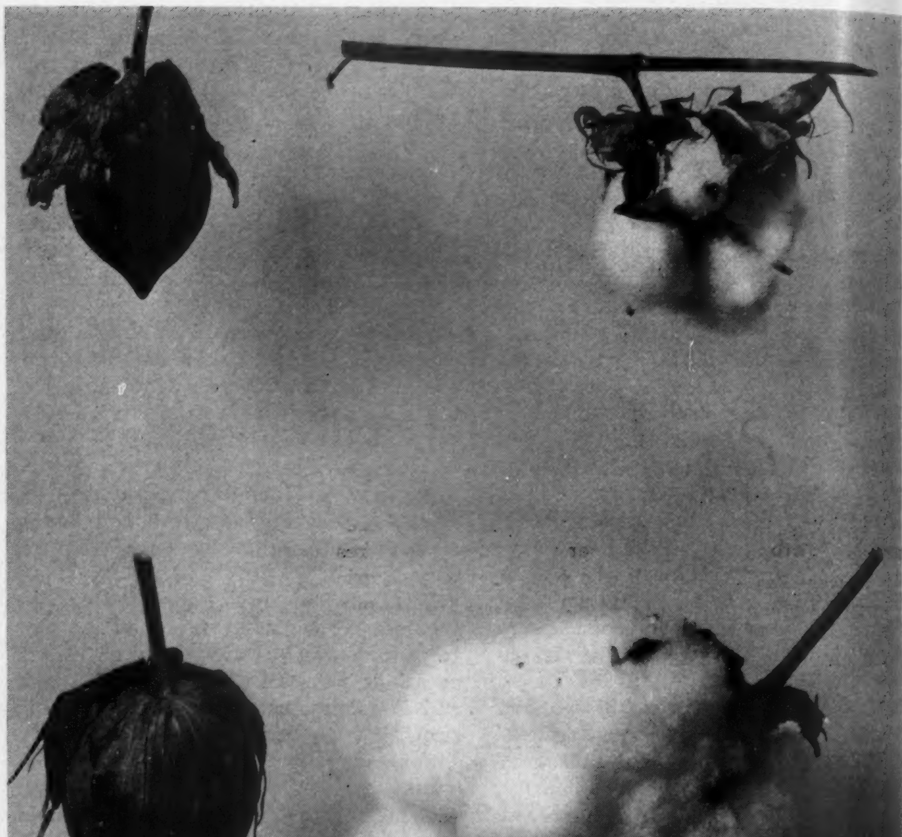
The westward-moving pioneers did enrich their soil with potash at least once. But they didn't know it. They burned trees and brush as they cleared the land, and the rains washed potash salts out of the ashes and into the soil. Lye from wood ashes (a crude type of potassium carbonate) was known as long ago as Aristotle's



**UNLOADS CARS WITH EASE**

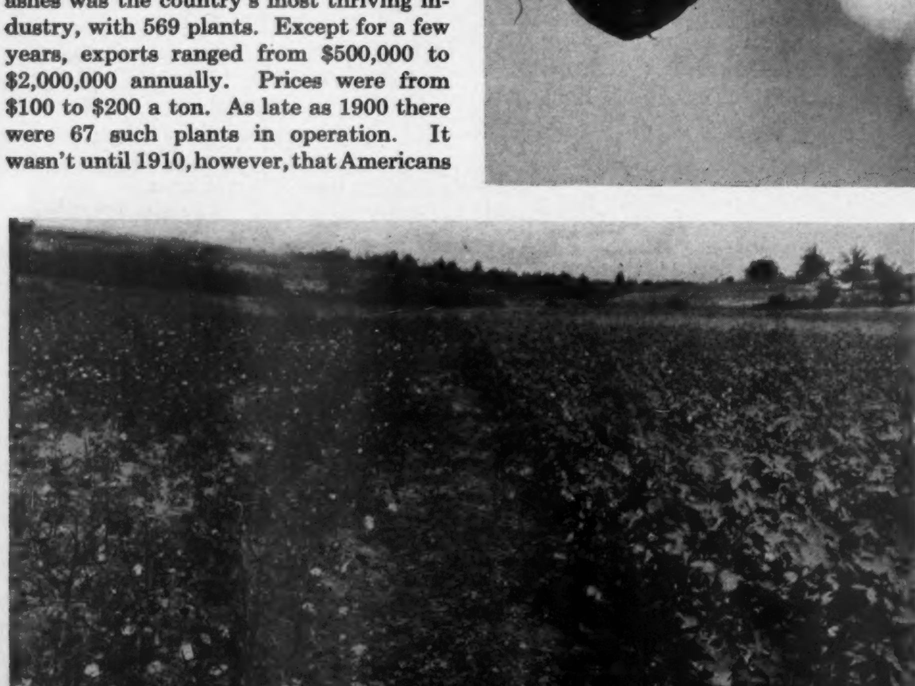
The rotary dump shown here is located at the shaft station of the Potash Company of America mine. As a train arrives from the face, the unloader grips each car and turns it over, discharging the potash on to a conveyor. This carries it to a crusher, from which the material passes through a pocket and hopper to a skip loader for hoisting up the shaft to the surface plant.

time, but not for fertilizing the soil. It served the Bohemians in the sixteenth century in the manufacture of a fine-quality glassware. In American colonial days this lye, a form of potash, was much used in soap-making. Men skilled in producing "pot-ashes" crossed the Atlantic with the earliest settlers, along with other artisans, to help build a new civilization.



H. I. Smith, chief of the Mining Division, U. S. Geological Survey, relates in an article entitled *Three and a Quarter Centuries of the Potash Industry in America* that South Carolina subsidized the manufacture and exportation of potash in 1707. Massachusetts enacted measures to encourage its production in 1735; Rhode Island granted a potash monopoly in 1753; and by 1750 American potash was finding its way into English markets, duty free, chiefly for soap-making. During the Revolution, Mr. Smith continues, production dwindled to such an extent that Massachusetts advertised a bounty of "100 pounds a ton" for potash manufactured in the United States and accepted potash in lieu of taxes. And that was before they knew what potash would do for their soils!

After the Revolution, the industry took a new start. Exports increased, and by 1850 the production of potash from wood ashes was the country's most thriving industry, with 569 plants. Except for a few years, exports ranged from $500,000 to $2,000,000 annually. Prices were from $100 to $200 a ton. As late as 1900 there were 67 such plants in operation. It wasn't until 1910, however, that Americans as a whole began to realize how much they were dependent upon potash for the food they ate and for the maintenance of their expanding chemical industries. At that time the Germans, who had been supplying the world, suddenly reversed their trade policies and canceled all contracts in this country. American concerns dealing in potash lost $28,000,000 well-nigh overnight.



Photos, American Potash Institute, Inc.

**STUDIES IN CONTRASTS**

Directly above is a field of cotton grown in Georgia to show the beneficial effects of potash. The severe defoliation in the case of the plants at the left is characteristic of cotton suffering from a lack of that fertilizer. Just what insufficient potash does to the cotton bolls themselves is illustrated at the top.

By 1914, when the war in Europe started, American farmers and industries keenly felt the potash shortage. The former were trying to boost the food output, and the scramble to meet potash requirements was very much like the scramble today for rubber. The job was about as tough, too. The price of potash jumped from $38 to $600 a ton. Here was an incentive, and it opened the door to the production of potash from many sources. But most of them proved too costly to survive the peace, when German potash came back on the market. However, by the end of the war America was making 45,000 tons (less than a tenth of our 1940 production) from brines, kelp, wood and cottonseed-hull ashes, alunite, green sand, and as a by-product of the cement-making and metallurgical industries. Only one of these war-born industries continued to

function after the war—the American Potash & Chemical Corporation at Trona, Calif., operating on Searles Lake. It cost this country approximately $50,000,000 to get its wartime potash.

As early as 1911 forces had been set in motion to scour the country for adequate domestic sources of potash. Even at that time the U. S. Geological Survey suggested the possibility of finding subsurface beds in the Permian basin extending from western Texas north through New Mexico and into Oklahoma, Kansas, and Colorado. But extensive explorations were not started there until 1926, after well drillers near Carlsbad, N. Mex., had discovered potash in beds 1,000 feet below the ground surface. As a result of test core drilling by the Geological Survey, potash minerals in the Permian basin were found to be present in an area covering 43,033 square miles. Of these, 40,000 square miles is a prospective source of the mineral, 33 square miles a proven source, and 3,000 square miles are known to contain potash. The government promptly withdrew the choicest potash lands to protect this valuable resource for the American people.

"From a chemist's standpoint," says Mr. Smith, "this was one of the greatest crystal crops ever harvested by nature." He thinks the deposits are probably of oceanic origin. The most promising part of the entire section was ascertained to be about 20 miles east of Carlsbad. Here was discovered the first sylvite, the richest form of mineral potash. According to R. M. Magraw of the Potash Company of America, which is operating there, it was the first find of its kind in the New World. The deposit is from 12 to 14 feet thick, and quite extensive. Three large companies are now established near Carlsbad. The United States Potash Company put down the first shaft in January, 1931. Later that year the Potash Company of America started drilling. The International Minerals & Chemical Corporation entered the field in 1936. All lease from the Government and are under Government supervision. Although many technical difficulties have had to be overcome in building up this brand-new industry, the total output of these mines in 1940 was 658,249 short tons of merchantable potash salts valued at $12,562,050. Both production and consumption have been growing from year to year.

Potash is mined about the same as coal, using the room-and-pillar system. This means that the salts are dug out in rooms separated by thick pillars that are left standing to support the roof and that are subsequently worked. The material looks like a beautiful reddish rock salt. The mines are modern; there is not dust; and the temperature is 68°F.

The rich sylvite body represents an interlude in the history of the Permian Sea, according to T. M. Cramer of the United States Potash Company. Great

**SURFACE STRUCTURES**

The fine headframe on the property operated by the United States Potash Company. All the mines in the Carlsbad area are of recent development and modern in every respect.

thicknesses of anhydrite and salt were laid down before nature was ready to create a potash bed 10 feet thick. Then another great layer of salt was laid on top, as if to protect the more precious deposit. As it turned out, it was discovered just when man began to understand the value of potash in enriching the soil. It required thousands of years to create the first salt body, said Mr. Cramer back in 1938 when addressing a technical conference on potash at Dallas, Tex., but it took only a man's life span—a split-second of geologic time—to superimpose the concentrated potash salts and to give America all the potash it can use for a long time to come.

Approximately 90 per cent of the potash salts from the Carlsbad beds goes into commercial fertilizers, while the remainder does a whopping job for our gigantic and extremely important chemical industry. The electrochemical branches are the largest consumers of potash chemicals, according to J. W. Turrentine, president of the American Potash Institute, Inc. Potassium chloride (the form in which potash is mined) is converted into caustic potash mainly for chemical purposes and is, in turn, converted into potassium carbonate, one of chemistry's greatest servants.

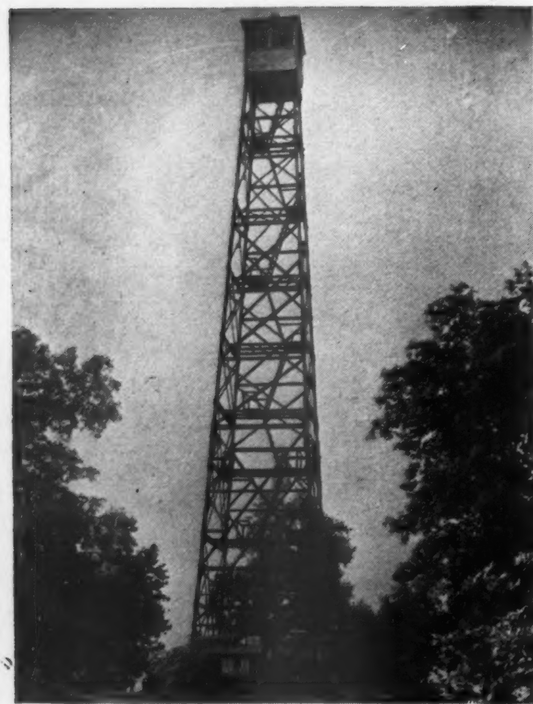
More than 100 commercial potassium salts were enumerated by a trade paper in 1934, and the industrial applications filled three pages. Horace M. Albright, in *The Romance of American Potash*, gives the following brief list of principal uses:

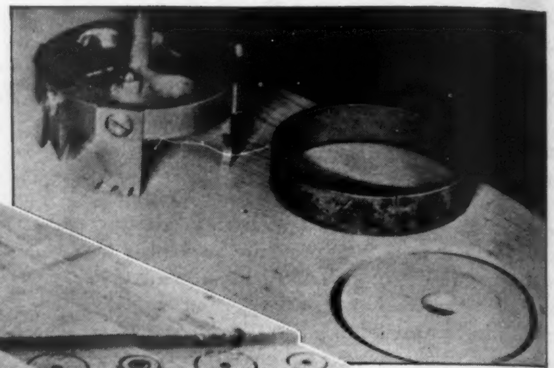
| | |
|---|---|
| Fertilizers | Mineral waters |
| Medicine | Papers |
| Glass | Disinfectants |
| Soap | Bleaching |
| Cleaning compounds | Pickling meats |
| Safety matches | Fruit drying |
| Electroplating | Perfumes |
| Printing | Analytical chemistry |
| Glue | Wood stains |
| Explosives | Adhesives |
| Tanning leather | Steel |
| Baking | Pyrotechnics |
| Photography | Bleaching oils |
| Textiles | Fumigants |
| Dyes | Fly Paper |
| Lithography | Absorbent in masks |

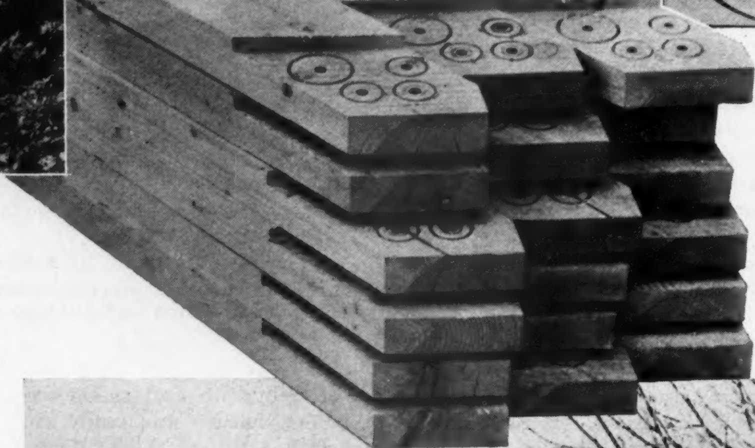
The potash industry of America is still young, and so is the field of potassium research. Additional compounds are continually being made and put to new uses. The availability of the mineral encourages laboratory work, and chemists are bent upon solving the mystery of that secret process of nature by which kelp absorbs potassium from sea water and somehow filters out the salt. There is a great deal of potash in sea water. Meanwhile, more and more potash is serving to feed farm soils so as to make our lands more productive.

Since the first World War, extensive potash deposits have been discovered in other countries, particularly in Russia—in fact, potash is now a world commodity like nitrate and phosphates. It is comforting to know that the United States will never again have to depend upon foreign sources of supply for this vital commodity, which is so essential to our very existence.

# Construction's Magic Rings







Official Photo OWI

**NEW TYPE OF JOINT**

At the top, right, are shown the ring connectors that are being used instead of bolts to join timbers. The idea originated in Sweden and was further developed in the United States. The pressed-steel rings or malleable iron plates are placed in circular grooves, center, where the timbers overlap and provide a far greater supporting area than do conventional bolts. This permits the substitution of wood for steel in building large structures. The 100-foot lookout tower, top left, stands in the Shawnee National Forest in Illinois and is 20 feet taller than previous structures of this kind. With bolted joints, the limit is 80 feet; the present maximum is 300 feet. Directly above is a 100-foot arch bridge that could not have been constructed of wood but for the new connectors.

FROM the Office of War Information we learn that the judicious use of timber has conserved as much as 200,000 tons of structural steel in a single military construction program, and that, all in all, more than 400,000 tons of steel was saved in this manner during 1942. Much of the credit for this impressive conservation can be given to the metal timber connector—pressed-steel rings or malleable iron plates ranging from 2½ to 6 inches in diameter. When placed in circular grooves between adjacent faces of overlapping timbers, they provide larger supporting areas than those obtained by other joining methods. By contrast, relatively small supporting areas are furnished by bolts, which are customarily used for this purpose. The addition of a timber connector makes it possible to distribute the load more equally over the cross section of the wood and thus utilize more fully the structural strength of the timber itself.

Under the Government war program, numerous towers, bridges, hangars, warehouses, and other structures have been erected of wood by means of timber connectors with astonishing results. For example, wood towers built before the development of the new technique were limited to a height of 80 feet—the height being restricted because of the weakness of the supporting joints. But now, structures of this kind, meeting all engineering requirements and specifications, sometimes reach an elevation of 300 feet. Moreover, the savings in critical metal are often startling, even in cases of individual buildings. For instance, the use of timber connectors in a blimp hangar 1,000 feet long, 153 feet high, and having a roof span of 237 feet, enabled the Navy to construct it of wood and thus save about 2,050 tons of structural steel.

# Log of Our War Economy

THE following paragraphs contain significant bits of information culled from official press releases sent out by the War Production Board.

MARCH 18—War workers soon will be able to buy alarm clocks again, the Consumers' Durable Goods Division said in reporting on the WPB program to produce 1,700,000 spring-wound clocks for civilian use. The new models require only 7 pounds of brass and 400 pounds of steel, net, per 1,000, as against 394 pounds of brass and 818 pounds of steel, gross weight, for the prewar timepieces.

MARCH 19—A 48-hour work week throughout the steel industry was urged by the Steel Labor Advisory Committee at its first meeting with Steel Division officials. The purpose of this recommendation was to provide manpower for increased production and to compensate for the loss of workers to the armed services. The committee pointed out that to date the War Manpower Commission has established the 48-hour work week only in areas designated as critical from the standpoint of labor shortages.

MARCH 20—To assist in the fabrication of 13,000 to 14,000 farm tractors, Rubber Director William M. Jeffers released from inventory enough wide-base tires to equal the number of parts already in manufacturers' hands. This action will not require new production of large-sized rear tires but will merely necessitate the making of 3,000 to 4,000 small front-wheel tires to complete the machines.

MARCH 21—According to WPB's Tools Division, the most commonly used cutting tools are milling cutters, twist drills, taps, reamers, broaches, and cemented carbide-tipped tools. The production of cutting implements during 1942 was valued at $400,000,000. This year, said George H. Johnson, Director of the Tools Division, output must be raised to about $500,000,000 in order to provide the cutting tools required for the war-production program.

It has been announced that the basic trend of war production continues to be upward, although there were fluctuations in the December-January-February period. December output was unusually high because of year-end adjustments, and as a result January production declined. However, it picked up substantially in February, and average daily expenditures by Government agencies for war purposes reached a new high of $253,400,000. It was estimated by WPB that about three-fourths of our war-production effort in 1943 will be devoted to making weapons and ships.

MARCH 24—Collections of waste kitchen fats from the nation's households during January increased nearly 900,000 pounds over the preceding month, it was announced by Paul C. Cabot, Director of the Salvage Division. "Total collections for January amounted to 5,986,023 pounds," he stated, but added that the amount is still far short of the quantity needed. Waste kitchen fats are an important source of glycerine, which is one of our most vital war materials.

MARCH 26—It was announced that shipments of iron and steel scrap to consuming mills during January totaled 2,078,000 net tons, or approximately 16 per cent of the 13,000,000-ton quota for the first six months of 1943.

MARCH 29—A total of 157 war workers from eighteen states were named by War Production Drive Headquarters as winners of national honors for suggestions that increase and improve production. Thousands of man-hours and many tons of critical materials will be saved as a result, as evidenced by the fact that 37 of them that can be statistically measured will save 176,000 man-hours annually.

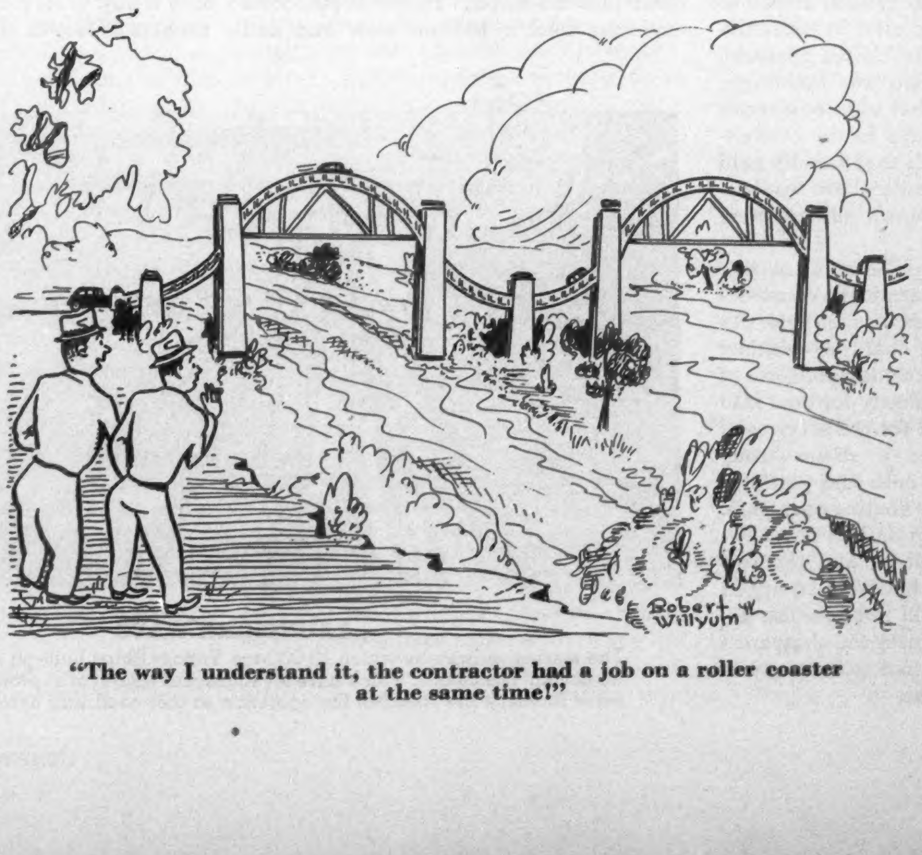
APRIL 2—More than 888,000 pounds (approximately 18,000,000 pairs) of discarded silk and nylon stockings have been voluntarily contributed by the women of America for war production during the first four months of the Stocking Salvage Campaign.

APRIL 4—The OPA reported that the use of fuel oil for heating in the seventeen eastern states and the District of Columbia had been cut to 60 per cent of normal during the six months between October 1 and March 31. Despite the critical nature of the oil shortage, the civilian population received its minimum requirements, and no plant producing essential war material was seriously hindered by a lack of oil. In addition, the mounting demands of the armed forces were fully met.

APRIL 5—It has been pointed out by the OWI that the conservation of rubber for war purposes is not confined to civilian economy. The Army also has promulgated active measures that effect tremendous savings. The War Department estimates that the program has reduced the use of crude rubber in the services by 45 per cent.

Inflated prices of used commercial motor vehicles were punctured by OPA which issued a regulation bringing such conveyances under price control. According to OPA, speculators have in some instances caused the prices of used trucks to rise 200 per cent or more over their normal value and have withheld many from the market in anticipation of higher prices resulting from shortages.

Rubber Director William M. Jeffers and Secretary of Agriculture Claude R. Wickard announced that the Guayule Emergency Rubber Program is being curtailed in order to minimize interference with the production of food crops. Since the outlook for synthetic rubber has become somewhat more clarified, irrigated land, according to these officials, that is leased but not already planted to guayule will be turned back to the owners immediately, if that is possible, or it will be subleased for food production.




**"The way I understand it, the contractor had a job on a roller coaster at the same time!"**

## A Friend Passes

WILLIAM RUSSELL GRACE, for many years first vice-president and director of Ingersoll-Rand Company, died of a heart attack at his winter home, "Two Trees," Aiken, S. C., on March 31, 1943, in his sixty-fifth year. His loss will be felt keenly by Compressed Air Magazine, of which he had long been a friend. Older members of the staff can remember how he helped guide the publication through several difficult periods and shape many of its successful policies.

Mr. Grace was born in New York City April 11, 1878, the son of William Russell Grace and Lilius Gilchrest Grace. His father was the founder of the international trading and shipping firm of W. R. Grace & Company and was twice Mayor of New York City. William Russell Grace, Jr., grew up at the family home, "Gracefield," at Great Neck, Long Island, and was educated at Columbia University, a member of the class of 1900. As a young man he received his first business training in the firm of W. R. Grace & Company, but he soon joined the Ingersoll-Sergeant Drill Company, manufacturers of mining and contractors' machinery. He played an important part in the development of this concern and in its merger, in 1905, with the Rand Drill Company under the name of Ingersoll-Rand Company.

In the capacity of treasurer and, subsequently, of first vice-president of Ingersoll-Rand Company, Mr. Grace was actively associated with George Doubleday in the management and world expansion of the company, which introduced modern compressed-air and other industrial machinery into Europe, Africa, Australia, Latin America, and other countries and established branch factories in a number of them. Throughout his business career, Mr. Grace was director of W. R. Grace & Company and of various subsidiaries of Ingersoll-Rand Company. He was also a director and vice-president of the Grace Institute of New York City, which was founded by his father for the training of young women in business and home economics.

Mr. Grace was an enthusiastic polo player and steeplechase rider in his youth. He continued his interest in these sports throughout his life and bred many famous polo mounts. He was for years a member of the polo committee of the Meadow Brook Club and of the American Polo Association. He was also a member of the following clubs: Links, India House, Downtown Association, Columbia University, Racquet and Tennis of New York City, Piping Rock, and Turf and Field. He belonged to the United Hunts Racing Association; Polo Club, Aiken, C.S.; Hunt Club, Orange County, Va.; the Royal Automobile Club of London, and the Alpha Delta Phi Fraternity of Columbia University. His country home was "The Crossroads" at Old Westbury, Long Island.

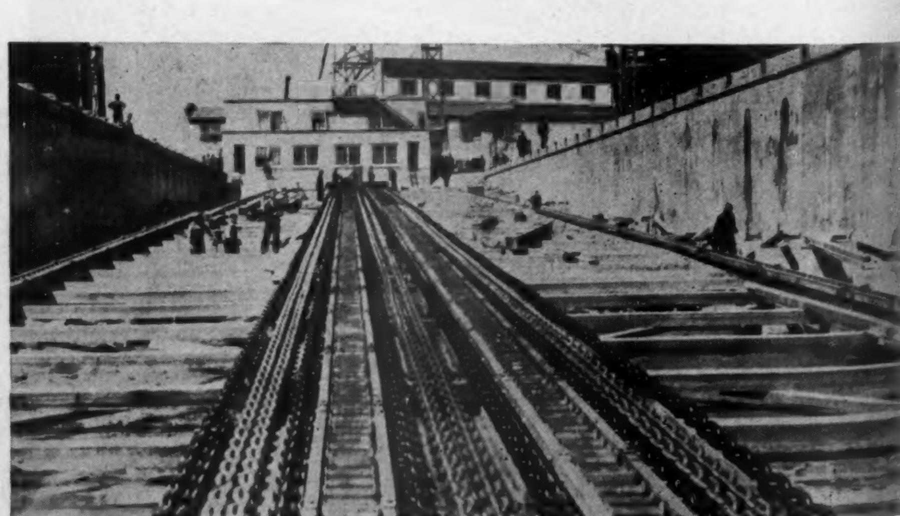
Mr. Grace was married in April, 1914, to Miss Elise W. Ladew of Glen Cove, Long Island. He is survived by his wife and his three daughters—Mrs. Augustus S. Blagden, Jr. of Ambler, Pa.; Mrs. F. J. Byers, Jr., of Sewickley, Pa.; and Mrs. Alan L. Corey, Jr., of Old Westbury, Long Island. Also surviving are his elder brother, J. P. Grace, chairman of W. R. Grace & Company, and his sisters, Mrs. George Edward Kent of Jericho, Long Island, and Miss Louise N. Grace of Great Neck, Long Island.

## Ship Launching by Marine Railway

WHAT is said to be the longest cast-steel chain ever manufactured in Canada is an achievement of which Sorel Steel Foundries Limited may well be proud. It is just another example of how new and difficult production problems, resulting from the war, are dealt with by this and other companies in the Dominion and the United States. The order was placed by a shipbuilding firm, which is constructing 10,000-ton vessels, known as Victory Ships, that are vital in maintaining the life line to the United Nations. The concern in question was building a new yard on a river that was too narrow to launch the large hulls in the conventional manner by which they rapidly gain momentum—the opposite shore was too close to the site to permit sliding them down the ways.

The answer to the problem was a marine railway which would permit the construction of a series of vessels on each side. As one was completed, it could be winched into place upon the launching platform of the railroad and thus slowly lowered into the water. This called for the services of a restraining medium—a chain strong enough to hold back both the platform and the hull during the floating operation. A chain of this description had never before been cast in Canada, and the two American companies that were equipped to handle the job could not promise delivery for a year. To meet the shipyard's production schedule it had to be ready in two months, and it was.

The contract specified 1¼ miles of 2¼-inch chain to be cast in 90-foot lengths. It is made up of 8,400 links each weighing 38 pounds. As a chain is only as strong as its weakest link, one of the difficulties encountered in the course of its manufacture was that of determining whether or not each section would stand up under the drag to which it would be subjected when inching the platform with its heavy load down into the water. To test them, Sorel engineers took a 180-ton scow and had eight lugs welded around its sides. A hawser was run from each lug to the center of the scow and attached, in turn, to a 90-foot length of chain the free end of which was hooked to shear legs on the shore. When all the hoisting apparatus were operated, the scow was lifted a minimum of 27 inches, thus exerting on the chain a strain in excess of the maximum called for in the specifications. The marine railway is now in service and launching 10,000 tonners as fast as they are completed.



LAUNCHING WAYS
The marine railway by which 10,000-ton Victory Ships built on each side of it are launched. The chains, which have an aggregate weight of approximately 160 tons, serve to check the speed of the operation so that each hull can be slowly floated.


### Practicing What We Preach

SPEAKING in celebration of Pan-American Day, Cordell Hull, Secretary of State, emphasized again the high principles by which the American republics have been held together, despite the efforts of our enemies to create dissension among them. "We pay tribute," said Mr. Hull, "to the most successful example of coöperation between sovereign nations in modern history." These were no mere platitudes. As is his custom, Mr. Hull spoke bluntly, truthfully. To check the verity of his statements, one has only to review the progress that has been made in the cementing of Pan-American relations during the past decade.

One phase of this was exemplified by the First Pan-American Congress of Mining Engineering and Geology held in Santiago, Chile, between January 15 and January 23, 1942. The congress was organized and directed by the Institute of Mining Engineering of Chile and was officially authorized by the Government of Chile and by the South American Union of Engineering Associations. One of the most important resolutions adopted by it was that calling for the organization of a permanent Pan-American Institute of Mining Engineering and Geology.

Some of the fundamental purposes of the institute, as stated in the provisional statutes, are as follows: to supervise and coördinate geological, mining, and metallurgical studies in the Americas, with a view to achieving maximum benefits for each and every one of the American countries; to promote closer relations and the exchange of ideas among the mining, metallurgical, and geological engineers of America; to facilitate the exchange of publications, teachers, students, engineers, technicians, and industrialists engaged in mining and geology; and to encourage the establishment of institutes of technological research in each of the American countries.

Obviously, if the high purposes of the Pan-American Institute reach fulfillment, the organization will prove of tremendous value to mining men throughout North and South America. But even more important, we think, is the resolve that lies behind the plan. It shows once again that the Good-Neighbor policy has borne fruit; that hemispheric solidarity has gone beyond the stage of a beautiful dream and is now becoming fact.

### The Voice with the Smile

AMONG the millions of people that use the telephone each day there are a fortunate few endowed with "telephone personality"—the ability to greet callers cheerily, to invite friendliness and confidence by the very tones of their voices. Industrial organizations have long recognized the value of "the voice with the smile"—the voice and manner that can make friends by telephone. In fact, so widespread is this recognition that many executives have issued printed suggestions to their personnel—suggestions designed to foster good will via the mouthpiece and receiver. Some helpful recommendations in this respect have recently been published by the Elliott Service Company. The more important of these are:

Do not allow the telephone to continue ringing if you are near at hand. Stop your work and answer at once ..... State immediately the name of your department and your own name; that is, "Shipping Department, Taylor speaking" ..... Be pleasant. A grumpy voice can create an impression that may never be eradicated ..... Speak clearly. Don't mumble or swallow your words. Talk directly into the mouthpiece, but be careful not to "blast." Ordinary volume is sufficient ..... Courtesy demands that you be a good listener. When the other person is speaking, pay careful attention ..... Interruptions are irritating; a sign of rudeness. Avoid them. Let the other fellow do the talking until he gives you your cue to reply ..... Remember, the rules of politeness that govern face-to-face conversation also apply on the telephone .... it isn't hard to develop a telephone personality that will be pleasing to everyone.

### We Know We're in It

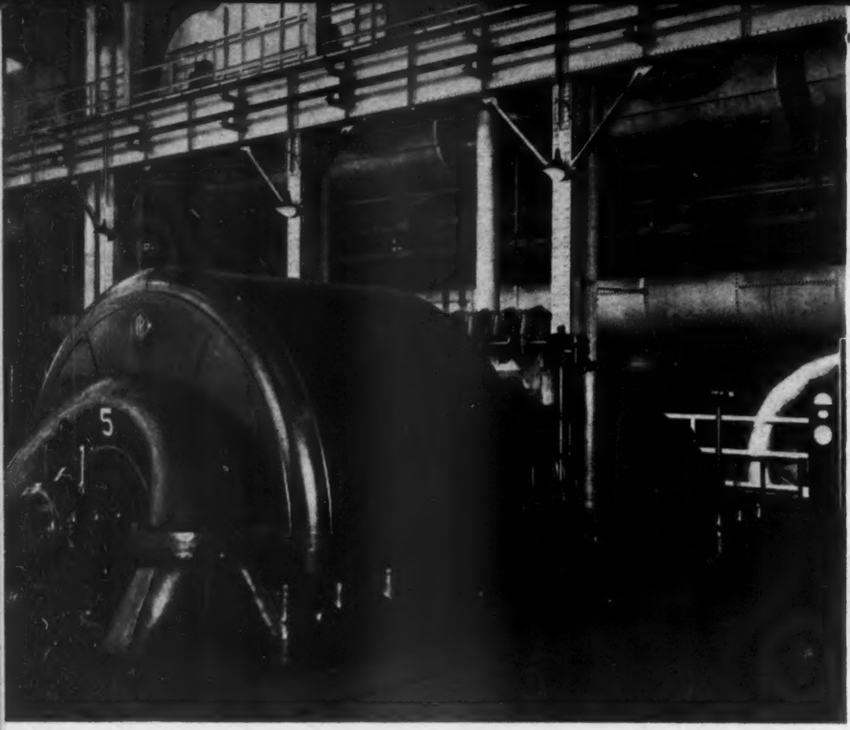
FOR several months after America's entrance into the war there were many in high places who worried about the public's lack of awareness. It was stated, perhaps justifiably, that many of us were overconfident, indifferent. What we needed, said the specialists in morale, was an honest-to-goodness scare or two—perhaps a token bombing to frighten us out of our mood of complacency.

But the mood, if it ever did exist, is no longer a bugaboo. One of the answers, of course, is found in the ever-growing rosters of our military forces. With millions of Americans now under arms there are few families that have not been touched directly or indirectly. But other reminders are with us, too.

In times past, the weather was commonly the favorite topic of conversation. The weather now runs a bad second. As a talking point, it has been replaced by discussions about canned goods, gasoline, tires, and shoes. The housewife knits her brows, purses her lips, and studies her charts. "How many points for a can of string beans?" has become a familiar refrain in households throughout the land.

But, to the everlasting credit of our people, these by-products of war have been received with good grace. Although the rationing system is admittedly not perfect, there is singularly little grumbling. Jane Doe is accepting the fact and adjusting her menus accordingly. John Doe has about decided that the Victory Garden will fill the gaps in the family pantry and that the attendant duties will pare down his waistline.

Yes, we know we're in a war. Every Tom, Dick, and Harry of us knows it. Our belts are tighter, but maybe our figures are better, too. And it didn't take a bombing attack to wake us up.





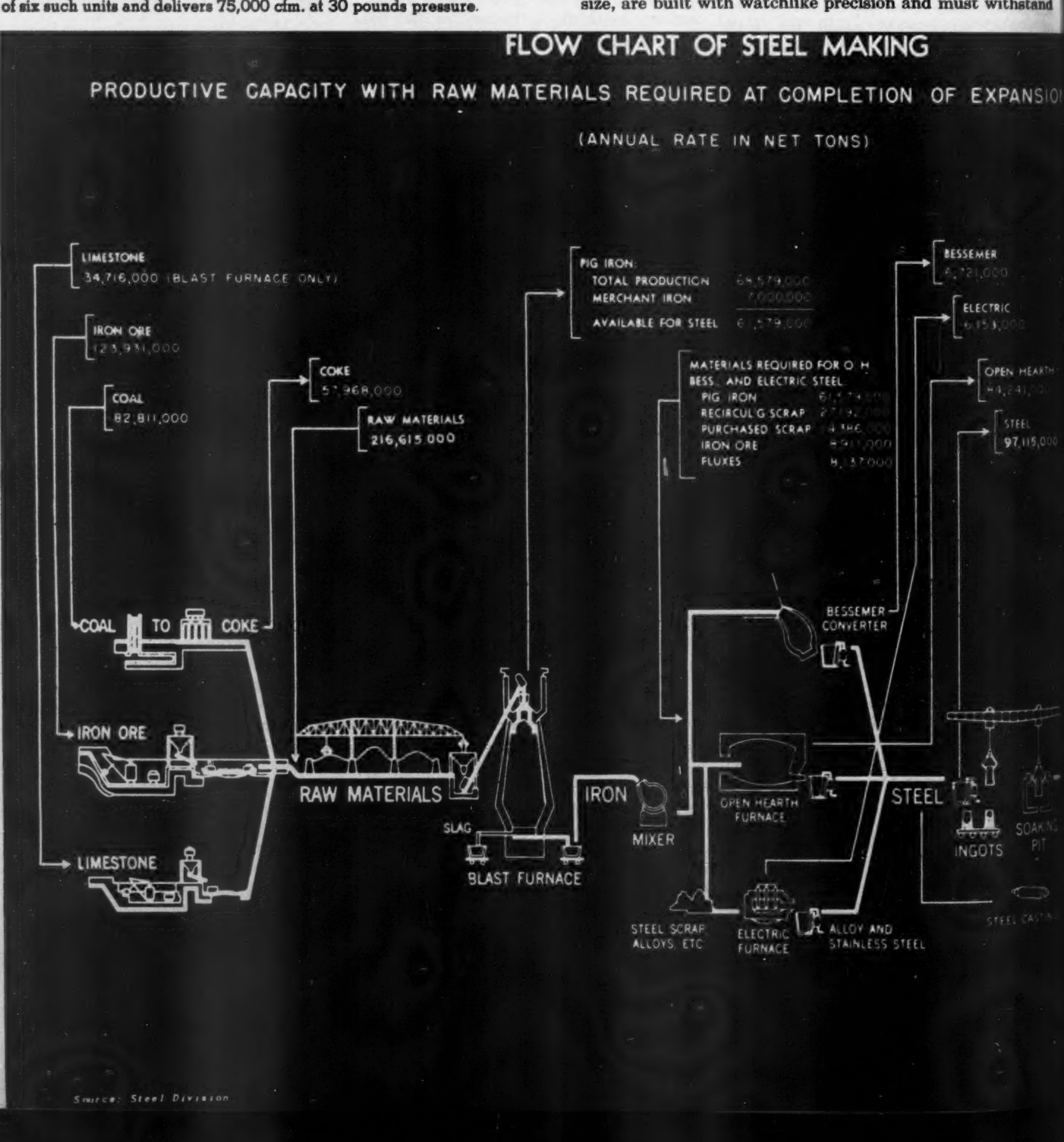
**TURBOBLOWER**
An 8,500-hp. blast-furnace blower serving a large steel plant. It is one of a battery of six such units and delivers 75,000 cfm. at 30 pounds pressure.

# Compressed

A STUDY of the accompanying War Production Board chart gives a graphic picture of the great steel program upon which we are engaged and which is so vital to our war efforts. It is estimated that by the middle of this year the steel-making capacity of the United States will be twice that of all the Axis countries, or 97,115,000 net tons annually —10,915,000 tons more than in 1942. The increase in our steel production naturally calls for corresponding increases in the tonnages of raw materials such as iron ore, coal, and limestone, as well as in the capacity of blast furnaces, open hearths, coke ovens, electric furnaces, etc.

Compressed air fits into this steel-making cycle from beginning to end. The air-powered rock drill and the slusher hoist speed the iron ore, coal, and limestone on their separate ways to the blast furnaces, into which turboblowers deliver the huge volumes of air that are required to reduce ore to molten pig iron. Part of the latter is transformed into steel by air blown through a Bessemer converter.

The blast-furnace blower is, in reality, the "lungs" of the furnace. Machines of this type, although of enormous size, are built with watchlike precision and must withstand



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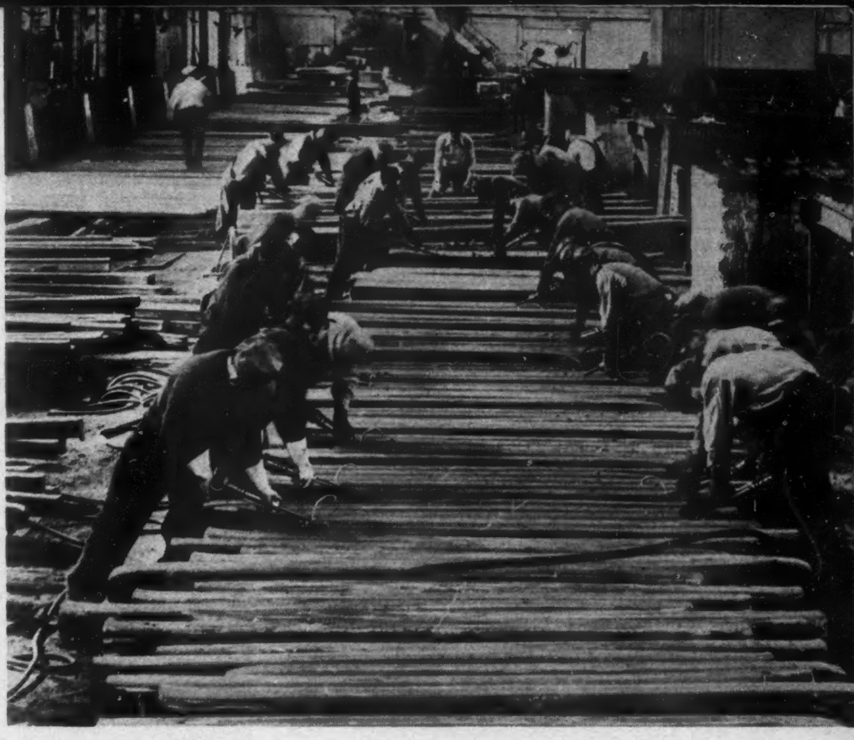
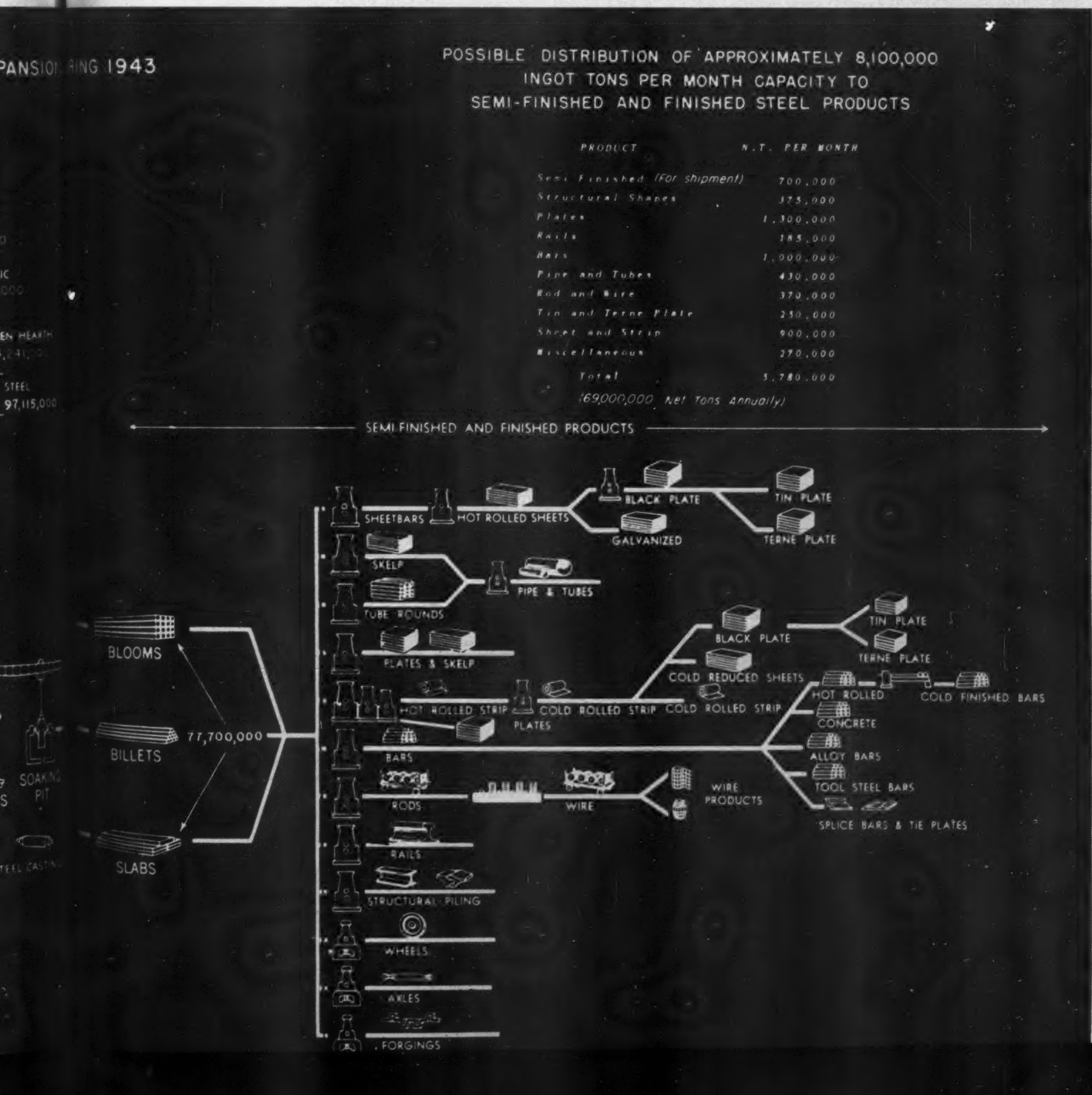
severe service. The blast pressure for northern ore is about 21 pounds per square inch and for southern ore about 25 pounds, gauge pressure. The weight of air delivered by the blower is slightly more than the weight of all the solid materials entering the furnace. When mild steel is produced by the Bessemer process the weight of the blast air is about 70 per cent of that of the steel produced. As a matter of fact, the average blower is said to deliver as much as 30 times its weight in air every 24 hours!

Many types of air tools are used to good effect throughout steel mills. Paving breakers serve to break up slag; chipping hammers and grinders are busy removing surface imperfections on billets; air hoists operate open-hearth furnace doors and lift loaded cradles from pickling vats; jets of air atomize tar or oil burned in the heating furnaces; impact wrenches are required where speed and tightness of assembly are important; and drills, chippers and riveters are needed for the work of fabrication and disassembly. Thus air power plays an indispensable part in both the day-by-day operation and the wartime expansion of our vital steel-making industry.



**AIR HAMMERS**

Chipping billets in a steel mill with portable, air-operated chipping hammers of the flapper-valve type. These tools are light in weight and low in air consumption.




| PRODUCT | N.T. PER MONTH |
|---|---|
| Semi Finished (For shipment) | 700,000 |
| Structural Shapes | 375,000 |
| Plates | 1,300,000 |
| Rails | 185,000 |
| Bars | 1,000,000 |
| Pipe and Tubes | 430,000 |
| Rod and Wire | 370,000 |
| Tin and Terne Plate | 250,000 |
| Sheet and Strip | 900,000 |
| Miscellaneous | 270,000 |
| Total | 5,780,000 |
| (69,000,000 Net Tons Annually) | |

## What We are Fighting For

FOR many years several members of our staff have spent their vacations on the chain of lakes that makes up the backbone of the Rideau Canal in Ontario. The bass and wall-eyed-pike fishing is often so good that it is like an angler's dream come true. Clint Fleming may or may not be the best guide—there is much difference of opinion on this subject—because Jim Simmons, Alan Alford, Bill Doyle, Ted Simmons, Fred Randolph, and George Franklin always give us a grand time and plenty of fish.

But Clint is the fellow who is always betting his customers a quarter that he can catch a fish in six throws; and brother, you'd better be careful of those bets, especially if you let him pick his spots, because six of his throws cover an awful lot of water, and he handles a plug in a way that the bass just can't resist. His letters are on a par with his fishing ability. He is well-read—knows what is to be known about many subjects the world over—and is a gentleman. He and his family have contributed more than their share to the war effort. In spite of everything, he still has his sense of humor and is a great storyteller. The following is an extract from one of his recent epistles:

"DINNER FISH"

J. C. Fleming, known to all and sundry as "Clint," is on the left of this stick of just-average large-mouthed bass, and R. W. Crannell, of Lehigh Foundries, Inc., Easton, Pa., is holding the other end.

"It has been lonesome up here this winter; in fact, so dead that people and horses don't leave any tracks in the snow. And even when 'whispering' Bill Doyle speaks in his melodious low voice it sounds like thunder. And cold—40°F. below! It's been so cold that people walk backwards all the time because if they don't their frozen breath piles up so high in front of them that they can't climb over. I wanted to write more, but the ink in my pen is freezing up and now I have to stop and put more logs in the fire. We had planned to come to the States to see you fellows this winter, but we have been running fish traps to help out with the food problem. The more bullheads we take out in the winter, the more bass you get the next summer."

Letters like this one from a Canadian guide bring home to us in the States what it means to live in freedom and to enjoy the many privileges that we have always taken for granted and that are now denied most peoples. It also emphasizes the harmonious relations existing between the two adjoining countries. Let us hope that when the war is won, a similar condition will prevail throughout the world.

## Industrial Notes

Work is in progress by the American Standards Association on a standard color code for lubricants of machine parts. The plan is to indicate by color on both the container and the machine part the grade of oil or grease to be used.

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Chanite is the name of a new alloy that is said to be suitable for making cutting tools. It is composed of minerals that have been neglected as alloying elements, and releases cobalt, tungsten, and other hard metals for more vital war needs. The composition is to remain a secret for the duration.

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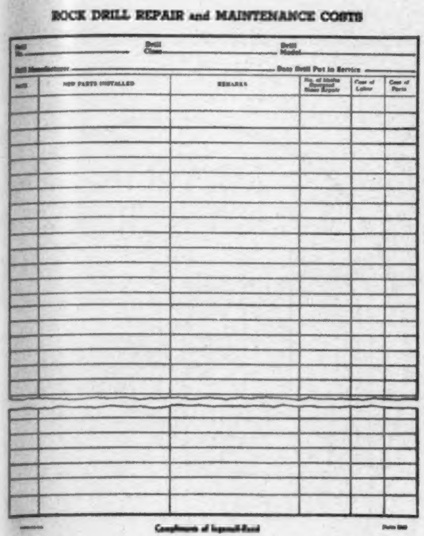
For some years the Ingersoll-Rand Company has supplied users of rock drills with sheets that enable them to maintain a complete record of maintenance costs for each of their drills. This sheet carries the identification, Form 2358. Appropriately headed columns are provided for recording detailed information such as the date the machine was put in service, its serial number, the name of the manufacturer, dates new parts are installed, number of shifts it has worked, cost of labor, cost of parts, etc. This sheet, which is 8½x11 inches in size, will fit in any stand-

and file. It is also punched so that it may be inserted in a standard 3-ring binder. The company calls attention to the sheet




at this time because conditions warrant closer control than ever before over repair parts, which require the use of valuable metals. Copies may be obtained from Ingersoll-Rand Company, 11 Broadway, New York City, or any of its service branches. When writing, specify the quantity desired.

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Swedish naval experts, according to foreign press reports, claim to have solved the problem of safeguarding ships against magnetic mines. Merchant craft leaving Stockholm are given "electrical massage" by passing them through a high-voltage field at a demagnetization station. Similar stations are planned for the southern and western coasts of that country. While complete demagnetization of the great mass of steel in a ship is, of course, not practicable, the "massage," together with the wiring of the outside of the hull, is said to protect a vessel against magnetic mines 30 or more feet beneath the keel.

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For making oil, grease, air, and other line connections between stationary and revolving, oscillating, or other moving parts, the Trabon Engineering Corporation has introduced a new line of straight and 90° angle swivels with and without ball bearings for different requirements. Those without are of the light-duty type and are designed for service where limited space does not permit the use of standard, ball-bearing swivels. The former are available only in 1/8 and 1/4-inch pipe sizes and the latter in six sizes ranging from 1/8 to 1 inch. Both are regularly furnished with right-hand threads in the head and stem; but swivels with left-hand threads in either head or stem, or in both, or of special materials, are made to order.

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For battery charging where electric current is not available, the Hunter-Hartman Corporation has announced a new portable generator that is designed to charge 6-, 12-, and 24-volt batteries at 10 to 300 amperes. The unit is driven by a 6-hp. gasoline engine, both mounted on a skid-type base with wheels that are raised when the equipment is in use to prevent creeping. By reversing the usual procedure—removing the battery, carrying it to the charging station, and replacing it—the battery remains where it is and the generator is brought alongside, thus effecting substantial savings in servicing time and in machine-hours lost through battery failure. Because of the critical materials that enter into the manufacture of the equipment it is available only to those that rate at least AA5 priority.

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The production of asphalt from deep-lying deposits has long presented a problem because of the material's viscosity. Attempts have been made to strip it from the intermixed sand formations by pumping hot water or emulsified hydrocarbon solvents into them. However, water alone was found to be inadequate, and organic solvents are both scarce and comparatively expensive. By a new method, on which a patent has recently been granted in the United States, the mineral is "mined" by a hot-water-and-soap solution to which a small quantity of some hydrocarbon solvent may be added. This is forced through drill holes into and through the underground deposits, separating the asphalt from the sand and delivering it by way of other drill holes to the surface. The scheme has military significance because asphalt is needed for building roads and airport landing fields.

# NOW... *More than ever*